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- Emmanuel College
- Harvard University
  - Medical School
  - School of Dental Medicine
  - School of Public Health
- Joslin Diabetes Center
- Massachusetts College of Pharmacy and Allied Health Sciences
- New England Deaconess Hospital
- Simmons College
- Wheelock College
- Winsor School

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November 24, 1987

Richard Dimino, Commissioner
Transportation Department
One City Hall Square
Boston, MA 02201

Dear Commissioner Dimino:

I am pleased to submit to you the first of three reports that comprise the Longwood Medical Area (LMA) Transportation Study. This Summary of Existing Conditions is the result of many months of hard work by our consultants, Vanasse/Hangen/Brustlin, LMA institutions, and MASCO planners. It represents the first time in twelve years that a comprehensive assessment of traffic conditions, transit service, parking, and journey-to-work data has been undertaken for this area.

In October, we met with members of your staff and the BRA to discuss preliminary findings and the schedule for release of the remaining two pieces of the study-- Growth Projections, and the Transportation Improvement Plan. We agreed, at that time, that the release of the other reports would follow a meeting with the Institutional Transportation Planning Advisory Committee (ITPAC). I believe this is also consistent with Ed Burke's plans for public review of the study.

Because evaluation and implementation of many of the improvement measures will be undertaken by or in conjunction with your department, I am requesting that the Transportation

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IN THE LONGWOOD MEDICAL AREA

Department call a meeting of ITPAC members to review the study's first phase report. If you are interested, we can arrange a briefing for you and key staff members prior to the ITPAC meeting.

Sincerely,

Rick Shea

Richard M. Shea, Jr.
Director of Area Planning

RMS/bjj
rl:rdnov24

cc: Ted Siegel, BTD
Chi'Hsin Shao, BTD
Stephen Coyle, BRA
Richard Garver, BRA
✓Larry Koff, BRA

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LONGWOOD MEDICAL AREA TRANSPORTATION STUDY

Medical Area Service Corporation (MASCO)

Vanasse Hangen Brustlin, Inc.

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TECHNICAL MEMORANDUM 1
Summary of Existing Conditions

November, 1987

LONGWOOD MEDICAL AREA
TRANSPORTATION STUDY

TECHNICAL MEMORANDUM #1
SUMMARY OF EXISTING CONDITIONS

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November, 1987

Prepared for

MEDICAL AREA SERVICE CORPORATION
(MASCO)

by

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I. Introduction

I. INTRODUCTION

A. DESCRIPTION OF THE LONGWOOD MEDICAL AREA

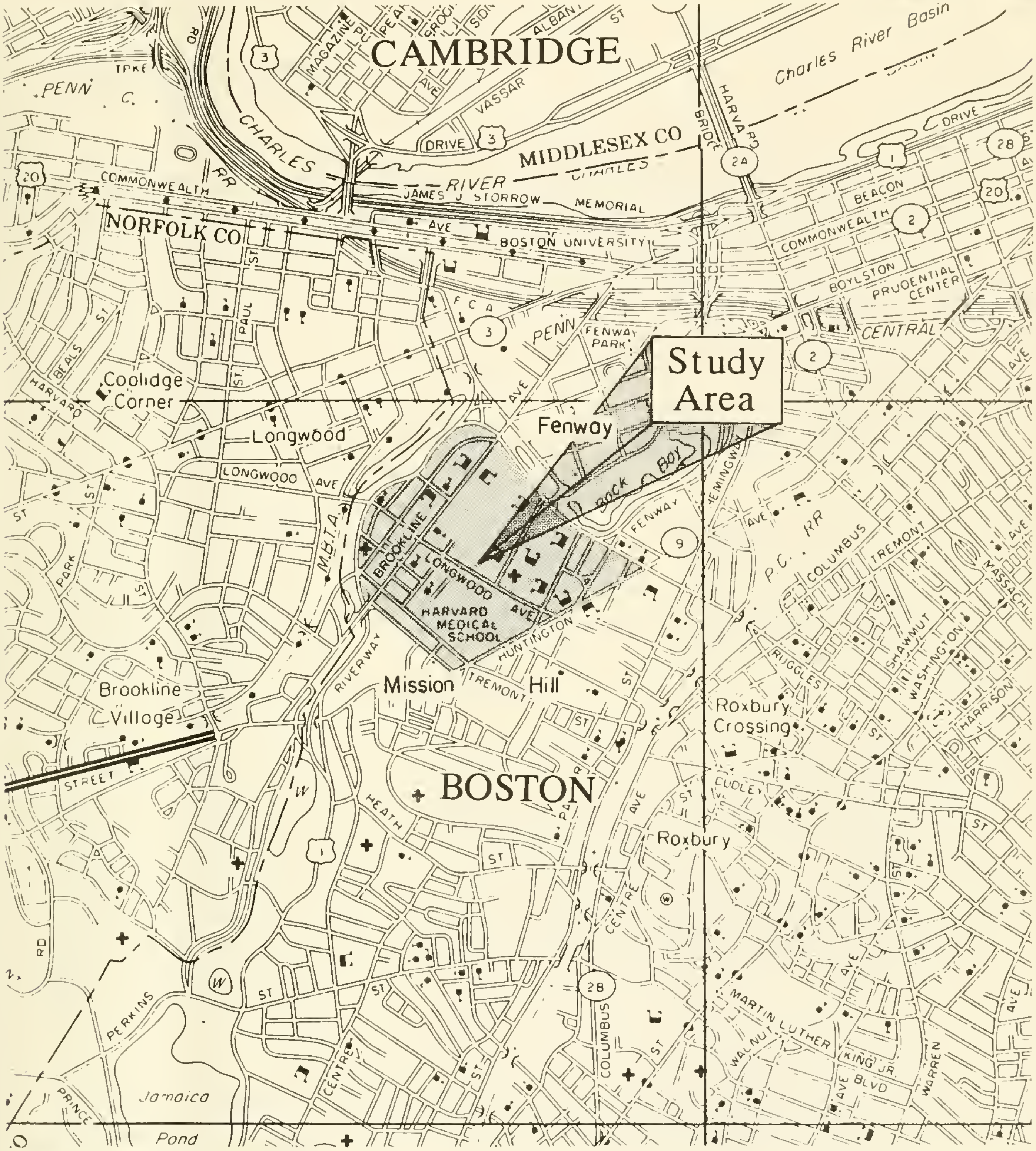
The Longwood Medical Area (LMA) is a 175-acre site located adjacent to the Fenway and Mission Hill neighborhoods of Boston. Its high concentration of institutions has grown over an eighty-year period to be one of the most prestigious centers of medical and educational service in the region and the country. The Medical Area Service Corporation (MASCO) is a shared service organization in the Longwood Medical Area. Created in 1972 by medical and educational institutions, MASCO assists its members as well as other non-profit institutions in carrying out their functions effectively and efficiently. MASCO's goals are: to reduce costs by utilizing substantial economies of scale; to provide employee and student support services; and to create a sense of community through area-wide planning and development efforts.

MASCO's 14 member institutions include four major teaching hospitals (Beth Israel, Brigham & Women's, Children's, and New England Deaconess), two important research treatment centers (Dana-Farber Cancer Institute and Joslin Diabetes Center), the Harvard Medical School, Harvard School of Dental Medicine, and Harvard School of Public Health, four other historic colleges (Emmanuel, Simmons, Wheelock, and Massachusetts College of Pharmacy and Allied Health Services), and a girls' preparatory school (The Winsor School). Non-member institutions located in the LMA include the state-owned Massachusetts College of Art and Massachusetts Mental Health Center, the city-owned Boston Latin High School and Boston English High School, and the private non-profit Judge Baker Children's Center and Temple Israel.

In total, these 20 institutions coexist with other land uses in an intensely urbanized area bounded by the Riverway, Fenway, and Huntington Avenue (see Figure 1). Adjacent to the LMA are the Town of Brookline and two Boston neighborhoods: the Fenway and Mission Hill. Also located nearby are other important Boston institutions, including the Museum of Fine Arts, Boston University, Wentworth Institute of Technology, and Northeastern University, to name a few. Downtown Boston lies just two miles to the northeast.

The LMA is traversed by several commuting routes to downtown Boston. As an activity center, downtown Boston continues to thrive, and the rate of new development is increasing. The combination of LMA land uses, its proximity to surrounding areas, and its location along major downtown commuting routes presents challenging transportation problems. Adding to this challenge is the need for additional development among the member institutions themselves in order to accommodate their own program needs.

To meet this challenge, MASCO has initiated this study with the support and cooperation of its member institutions. It is being coordinated with the City of Boston and the surrounding neighborhoods represented on the Institutional Transportation Planning Advisory Committee (ITPAC). The needs of an area encompassing the LMA and other major sections of the city will be further studied and coordinated among several studies which the City of Boston will initiate for the areas surrounding the LMA. This MASCO study is intended as the catalyst to present, in three volumes, an assessment of the existing transportation system, a five-year growth projection, and a set of recommendations as to how best to deal with the area's transportation needs.



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Study Area Location Map

Fig. 1

B. PROBLEM STATEMENT

In 1975, MASCO funded a study[1] which resulted in recommendations for transportation improvements for the LMA, many of which have since been implemented. This earlier study also identified five access and circulation problems which were projected to occur by 1985, including:

- Capacity constraints on arterial streets;
- Conflicts among pedestrians, traffic and the surrounding environment on local streets;
- Coverage by and access to public transportation;
- Clarity and security of pedestrian circulation; and
- Increased demand for parking.

A major result of this earlier study was the redefinition of Huntington Avenue, Brookline Avenue, the Riverway, Fenway and Longwood Avenue as arterial streets serving both through and local traffic movements. The study's authors foresaw serious transportation problems due to the inability of the existing roadways to handle the increasing volumes of traffic in, around, and through the LMA.

In general, the predictions of this earlier study have been realized. Transportation problems are in some instances even more severe than had been forecast, threatening the vitality of

---

1/ Charles G. Hilgenhurst & Associates and Wilbur Smith & Associates, "Transportation Planning for the Longwood Medical Area," 1975.

this unique area and its billion dollar economy. Many of the improvements and programs which were recommended in the earlier study, but have yet to be implemented, need to be further examined along with others in a comprehensive new analysis. Perspectives on the causes of traffic congestion and accessibility related to the LMA are abundant. Acceptable solutions may be harder to come by.

The transportation needs of the LMA should be addressed in the context of the users of the system of roadways, public transportation, and other transportation services provided. The transportation problems which exist can be categorized by issue and by impact. From this perspective, one can define both the dimensions of the problem and the range of solutions. Figure 2 summarizes the principal transportation and land use issues in the LMA. Although not an exhaustive listing, this chart provides a focus for the study by identifying six major issues and indicating how each issue affects each of four groups.

Commuters traveling through the LMA provide another important dimension to the identification of a transportation problem in the LMA. The implications of any solutions which attempt to meet transportation needs of the LMA must be considered in their citywide context as well. As Boston continues to thrive as an economic center, the proportion of commuter through traffic will remain significant and will continue to congest the corridors which lead into and through the LMA. A broad perspective is therefore needed to devise a transportation system which meets the LMA's needs as well as those of surrounding communities and the city.

LONGWOOD MEDICAL AREA TRANSPORTATION STUDY
ISSUES AND IMPACTS SUMMARY
PERTAINING TO FOCUS OF CURRENT STUDY

ISSUES

IMPACT ON:	Neighborhoods	Employees	Students/ Patients/Visitors	Institutions
Commuter "Through" Traffic	o Identify spillover traffic locations. o Outline measures to discourage traffic spillover into neighborhoods.	o Identify "time-of-day" trip characteristics and conflicts with "through" traffic. o Recommend alternative shift schedules to minimize peak hour convergence.	o Identify "time-of-day" characteristics and conflicts with "through" traffic. o Recommend alternative scheduling to minimize peak hour convergence.	o Measure conflicts with emergency trucks and vital delivery vehicles. o Recommend options for improvements.
Parking Supply	o Identify extent of peripheral lots within neighborhood environs. o Recommend general mitigation measures to address peripheral lot impacts.	o Identify "monthly" parking options and costs. o Evaluate parking management alternative strategies.	o Identify locations of short-term parking spaces. o Outline future options for short-term parking.	o Identify institutional parking strategies. o Recommend parking needs assessment methods.
Parking Demand	o Identify areas of "illegals" parking in resident-only spaces. o Outline enforcement measures needed to resolve illegal use of resident spaces.	o Measure existing and future employee demand. o Evaluate parking demand implications.	o Evaluate circulating traffic impacts. o Identify public parking options and strategies.	o Evaluate overall demand issue relative to growth. o Identify parking costing policies and their implications on demand.
Traffic Congestion	o Identify neighborhood cut-through traffic. o Recommend measures to discourage cut-through traffic and roadway management changes.	o Measure proportional share employee trips are of peak hour congestion. o Encourage/identify alternatives to reduce auto usage by employees.	o Assess time-of-day impacts of patient/student/visitor component trips. o Encourage/identify alternatives to auto trip mode.	o Identify site access standards and their relationship to traffic congestion. o Outline mitigation measures and site access improvements.
Transit Utilization	o Clarify transit service levels and user characteristics. o Recommend improvements where needed which serve area residents.	o Measure employee level of transit usage. o Evaluate improvement options and their relationship to increased transit usage.	o Estimate patient/student/visitor transit usage. o Recommend measures/incentives to encourage transit usage.	o Identify institutional policies toward transit use incentives. o Recommend comprehensive employee and visitor transit subsidy program.
Growth & Development	o Identify type and level of residential growth projected for LMA. o Estimate traffic impacts on surrounding areas and mitigation measures.	o Measure growth in employees trips projected. o Identify locational impacts, alternative roadway changes, and improvements to accommodate trips (i.e., one-way pairs, signal and roadway improvements, etc.).	o Measure growth in student/visitor/patient trips to LMA. o Identify locational impacts, alternative roadway changes, and improvements to accommodate trips (i.e., one-way pairs, signal and roadway improvements, etc.).	o Solicit and evaluate short-term growth expectations. o Identify by category increase in trips, locational impacts, alternative roadway options, and funding methods.

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Issues and Impacts Summary

Fig. 2

C. GOALS AND OBJECTIVES OF THE STUDY

To achieve results from the overall analysis of the elements of the transportation problem in the LMA, a few broad goals and many more specific objectives were established to guide the study team. The following summary of goals and objectives presents the concerns of MASCO, the City, and the public groups which have contributed toward the initiation of this study:

Goal 1

Thoroughly evaluate the existing transportation conditions in the LMA.

Objectives

- Present updated traffic information.
- Present updated parking information.
- Estimate the amount of "through" traffic on roadways in the LMA.
- Identify significant locations of traffic congestion.
- Summarize the public transit and special transportation services in the LMA.
- Present the system characteristics of the roadway network.
- Identify the needs of pedestrians.
- Provide an overall land use summary.
- Develop trip-generation rates for LMA employees and users.
- Survey and evaluate the distribution of LMA commuters regionally.

Goal 2

Develop a five-year growth projection and assess its impact on the LMA's transportation system.

Objectives

- Consider the additional trips from all new projects already approved.
- Project, from a survey of the member institutions, growth in size, services, employees, and resultant trips or levels of activity.
- Project the change in level of commuter "through" traffic.
- Evaluate the impacts on surrounding neighborhoods and communities.
- Identify significant locations of traffic congestion, parking needs, transit service needs, and related impacts.

Goal 3

Evaluate alternative transportation improvement options, both short-term and long-term.

Objectives

- Recommend effective vehicle trip reduction measures.
- Recommend immediate action measures to improve the performance of existing transportation capacity.
- Outline incentives to increase the use of public transportation.
- Recommend more significant roadway changes - both long-term and short-term.

- Outline and prioritize improvements to parking supply and management.
- Develop improvements that address the needs of pedestrians.
- Outline potential sources of funding and strategies to achieve improvements.

II. Existing Land Use

II. EXISTING LAND USE

The LMA can be characterized either as another "central business district" or as an "outer business district" in terms of its land use and self-contained economy. Such a comparison is justified by the very large workforce in the LMA as well as the tremendous number of visitor trips for personal or business-related activity.

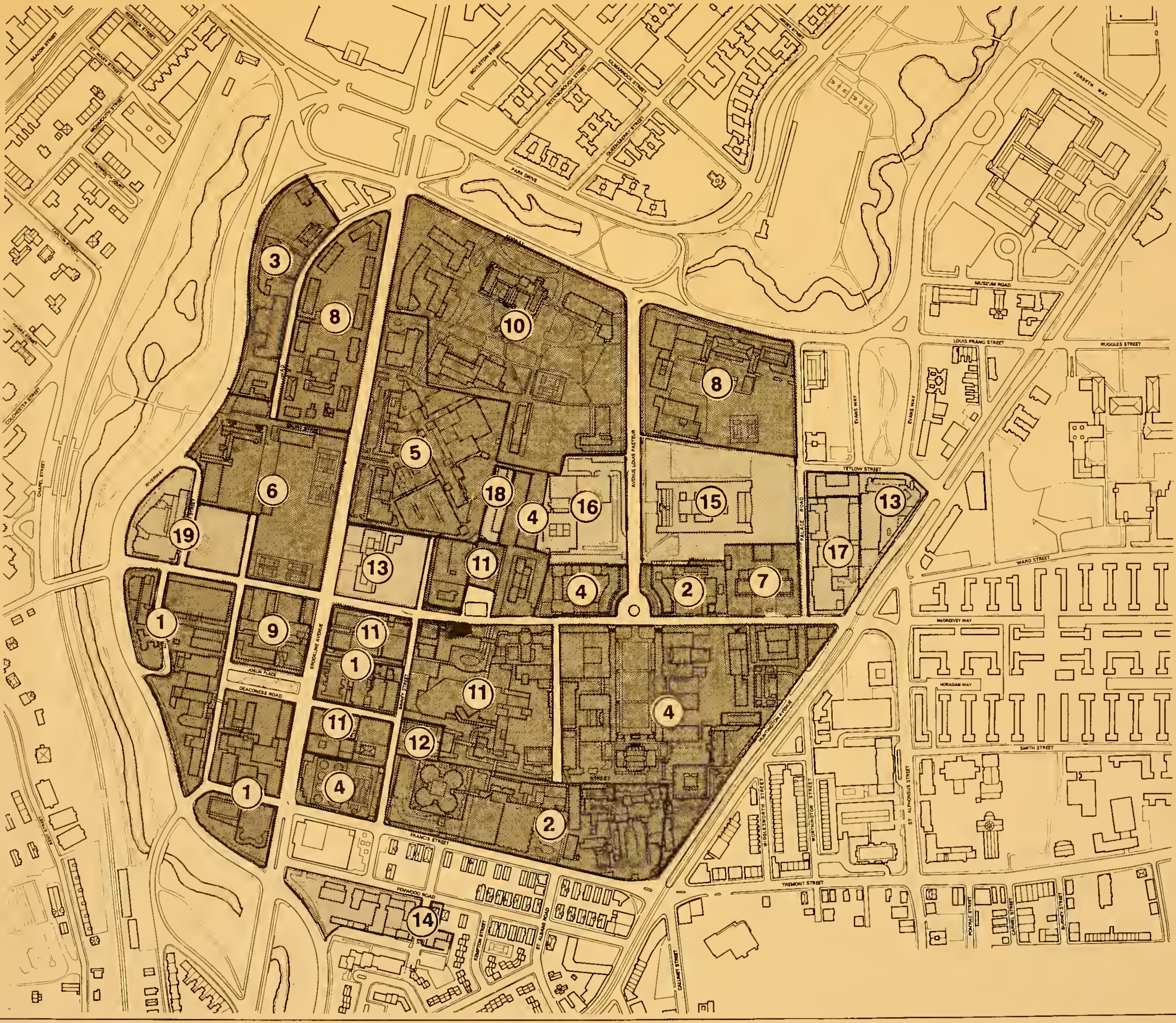
Yet, intuitively, the LMA represents a unique collection of institutional land uses which together have patterns of activity dissimilar to other business districts. A more appropriate analogy for the LMA might be a large and growing university, including a major teaching hospital, located in a rather cramped campus in a dense urban setting. This section of the study identifies these land uses in the LMA, the intensity of major activity centers, and the location of the existing parking supply.

Each of these characteristics relates to the number and time of day of trips to, from and within the LMA. The inventory of the existing land use is critical to form a basis to derive trip generation rates, project future conditions and ultimately seek transportation solutions to meet the needs of the area.

A. INSTITUTIONAL LAND USE SUMMARY

A map of institutional land ownership in the LMA is presented as Figure 3. Although some of the institutions are not MASCO members, the study considers the land use patterns and transportation needs of the LMA as a whole. The various kinds of LMA institutions display different land use intensities, as measured by floor area ratio (FAR), the ratio of building floor area to land area. The hospitals are characterized by higher FAR than

Land Ownership



1. *New England Deaconess Hospital
2. *Brigham & Women's Hospital
3. *Wheelock College
4. *Harvard Schools of Medicine, Dentistry & Public Health
5. *Beth Israel Hospital
6. *The Winsor School
7. *Mass. College of Pharmacy & Allied Sciences
8. *Simmons College
9. *Joslin Diabetes Center
10. *Emmanuel College
11. *Children's Hospital Medical Center
12. *Dana-Farber Cancer Institute
13. Mass. College of Art
14. Mass. Mental Health Center
15. Boston Latin High School
16. Boston English High School
17. Roxbury Community College
18. Judge Baker Children's Center
19. Temple Israel

*MASCO Members

LEGEND:

▩ **MASCO Member Institution**

☐ **Non-Member Institution**

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Fig. 3

the educational institutions. Comparison of the gross floor area of institutional use, presented in Table 1, with the land ownership information in Figure 3 reveals the variety of land use intensity within the LMA.

TABLE 1
GROSS FLOOR AREA BY INSTITUTION

Institution	Gross Floor Area of Occupied Space
Brigham & Women's Hospital	1,580 KSF*
Children's Hospital	1,320 KSF
Harvard Medical and Dental Schools	990 KSF
Beth Israel Hospital	930 KSF
Simmons College	610 KSF
New England Deaconess Hospital	480 KSF
Emmanuel College	430 KSF
Dana-Farber Cancer Institute	370 KSF
Harvard School of Public Health	350 KSF
Wheelock College	140 KSF
Joslin Diabetes Center	120 KSF
Mass. College of Pharmacy	100 KSF
Winsor School	100 KSF

* KSF = Thousand square feet.

Source: 1987 MASCO survey. Information was not available for the other LMA institutions.

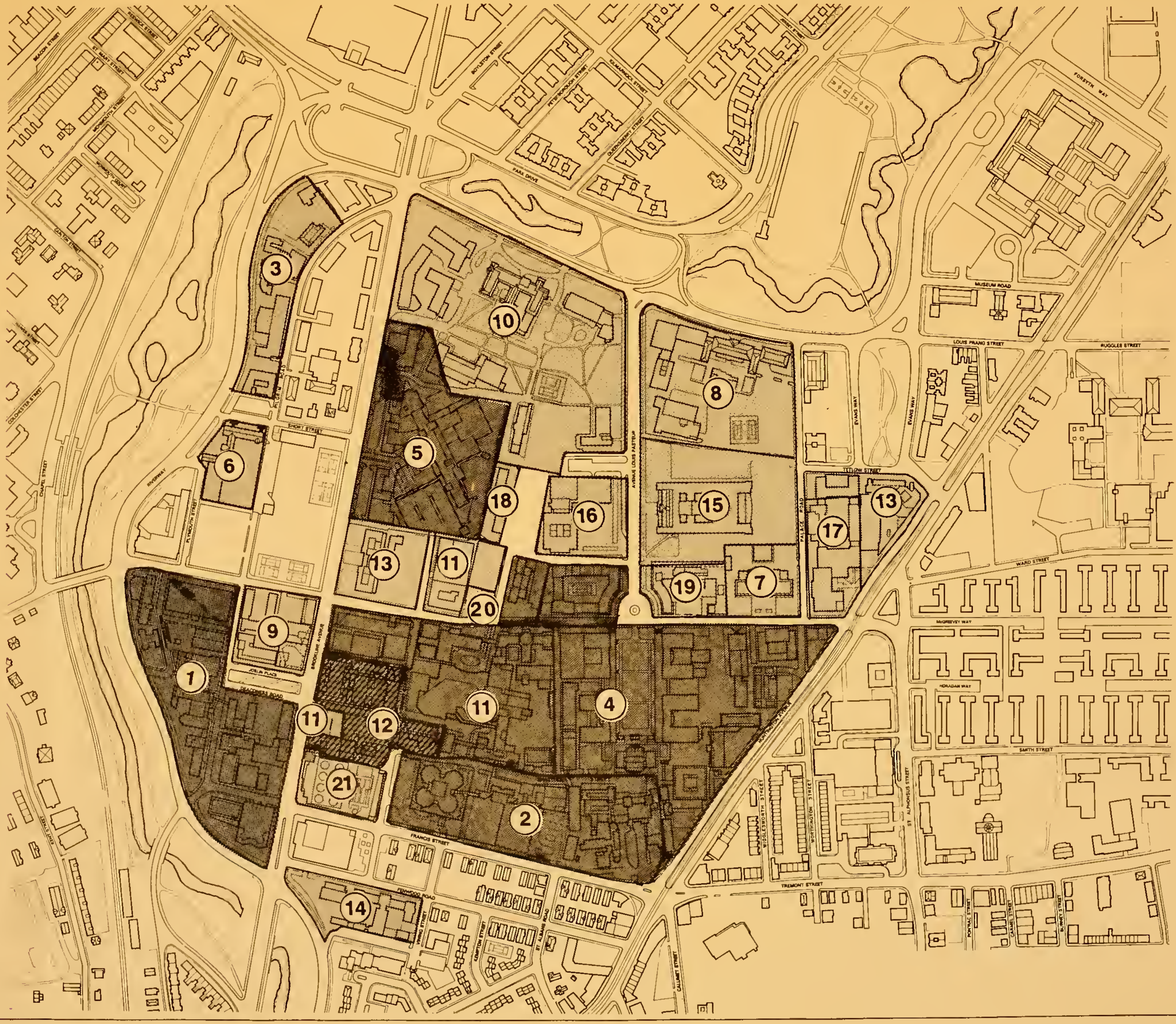
Just outside the LMA, to the west and north, substantial open space is found in the "Emerald Necklace" park lands designed by Frederick Law Olmsted. East and south of the LMA are mainly residential land uses, the preservation of which has required intense development of land within the LMA.

B. MAJOR ACTIVITY CENTERS

Transportation demand is derived from the level of human activity in a given location. Due to its land use characteristics, the LMA functions not as a single activity center, but as a set of activity centers comprising a complex urban sub-system. Gross floor area of building is one indication of the level of activity, but the use of that floor area is also critical since different levels of trip generation are associated with different uses.

It is difficult and very costly to quantify the transportation demands associated with such specialized land uses as are found in the LMA. However, one significant component of those demands, which is relatively simple to measure on a land use basis, is the number of workers employed at a given location. While LMA land uses actually generate less demand for work trips than for non-work trips on a daily basis, the work trip demand is perhaps the most important one to understand, for two reasons: (1) work trip demand normally comprises the majority of travel demand during peak travel hours, when the transportation system is most taxed; and (2) compared with non-work travel demand, work trip demand is to a greater degree subject to control and management by LMA institutions.

Figure 4 illustrates the geographic distribution of employment in the LMA. The heaviest concentration of workers is at the medical institutions.



Employment Densities

1. *New England Deaconess Hospital
2. *Brigham & Women's Hospital
3. *Wheelock College
4. *Harvard Schools of Medicine, Dentistry & Public Health
5. *Beth Israel Hospital
6. *The Winsor School
7. *Mass. College of Pharmacy & Allied Sciences
8. *Simmons College
9. *Joslin Diabetes Center
10. *Emmanuel College
11. *Children's Hospital Medical Center
12. *Dana-Farber Cancer Institute
13. Mass. College of Art
14. Mass. Mental Health Center
15. Boston Latin High School
16. Boston English High School
17. Roxbury Community College
18. Judge Baker Children's Center
19. Richardson Fuller Building
20. 319 Longwood Avenue
21. Medical Area Total Energy Plant

*MASCO Members

LEGEND:
Number of Employees
□ ≤500
▨ 501–2,500
■ 2,501–5,000

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Fig. 4

C. PARKING SUPPLY

1. Introduction

An inventory was made of all parking spaces within the study area (shown previously in Figure 1), regardless of ownership or control, plus all parking spaces outside the study area which are controlled by an LMA institution or by MASCO. This parking inventory includes curbside spaces in the study area and 70 off-street parking facilities within and outside of the study area. The off-street parking areas are controlled by 20 different institutions (in addition to MASCO). The inventory includes a total of 11,571 spaces, including 1,090 on public streets and 10,481 on private property. These facilities have many different pricing schedules and hours of operation. Some provide monthly permit parking, and some are open to the general public. The following sections provide a detailed account of these facilities.

2. Parking Inventory

The parking spaces inside the study area are classified as follows:

- Curbside parking spaces under the jurisdiction of the Boston Transportation Department, including metered and unmetered spaces open to the general public, spaces restricted to neighborhood residents with valid stickers, and spaces reserved for handicapped persons with special license plates;

- Curbside parking spaces along private roadways;

- Surface off-street parking spaces controlled by individual LMA institutions (including MASCO members and non-members);

- Surface off-street parking spaces controlled by MASCO;

- Parking structures controlled by individual LMA institutions (including MASCO members and non-members); and

- Parking structures controlled by MASCO.

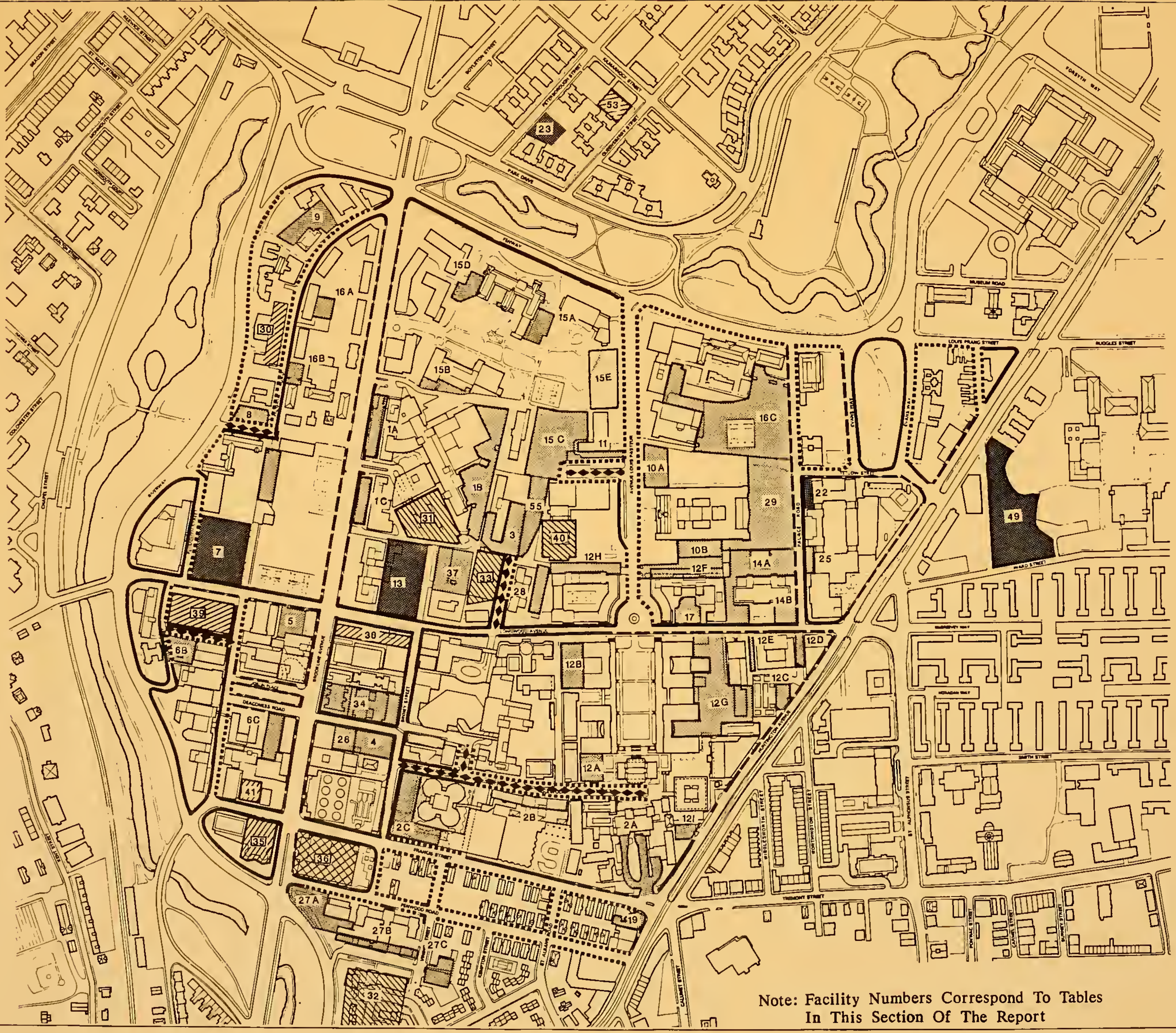
Parking facilities which lie outside the study area, but are controlled by an LMA institution or MASCO, are included in the inventory and are discussed on page 15.

The location of all parking spaces in the study area, both on-street and off-street, is illustrated in Figure 5. The figure also indicates the types of curbside parking spaces and off-street facilities. The latter are identified by a number code which corresponds to a series of tables presented in the text below.

• On-Street Parking in the Study Area

A detailed inventory of curbside parking spaces was conducted by MASCO during the fall of 1986. The results, updated as needed, are summarized in Table 2. There are 1,090 parking spaces on public streets in the study area. These spaces consist of 455 metered spaces open to the general public, 210 resident permit spaces, and 425 unmetered curbside spaces where parking is restricted to certain hours. An additional 121 curbside spaces are provided along private roadways, listed separately in Table 2. The curbside supply appears to be highly utilized during weekday business hours.

Study Area Parking Supply



Note: Facility Numbers Correspond To Tables
In This Section Of The Report

LEGEND:

Off-Street Parking
- ▩ MASCO Surface Parking
- ▒ Institutional Surface · Parking
- ⊠ MASCO Garage
- ▨ Institutional Garage

On-Street Parking:
- ◆◆◆ Private Way
- ━━ No Parking
- ······· On-Street (Resident, Restricted, HP or Private)
- ━ ━ Metered Parking

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Fig. 5

TABLE 2
CURBSIDE PARKING IN THE STUDY AREA

Street Name	Number of Spaces by Category Metered	Resident Permit*	Restricted Unmetered	Total
Autumn Street	0	0	15	15
Avenue Louis Pasteur	0	0	101	101
Binney Street	0	10	0	10
Brookline Avenue	165	0	3	168
Deaconess Road	24	0	2	26
Evans Way	18	0	19	37
Fenway	0	0	38	38
Fenwood Road	0	62	36	98
Francis Street	26	42	0	68
Huntington Avenue	75	0	61	136
Joslin Place	18	0	0	18
Longwood Avenue	59	0	0	59
Louis Prang Street	0	0	11	11
Palace Road	46	20	0	66
Pilgrim Road	0	52	26	78
Plymouth Street	0	0	15	15
Riverway	0	0	67	67
St. Albans Road	0	12	0	12
Tetlow Street	24	0	8	32
Vancouver Street	0	0	23	23
Vining Street	0	12	0	12
Total	455	210	425	1,090

PRIVATE WAYS

Blackfan Street	15
Pilgrim Road Garage Service Lane	14
Shattuck Street	88
Short Street	4
Total	121

---

* Resident permit spaces cannot legally be used by the general public; parking in these spaces is restricted to neighborhood residents.

• Off-Street Parking in the Study Area

There are four categories of off-street parking facilities in the study area. Facilities are either surface or structured parking and are controlled either by MASCO or by an individual institution. These four categories together contain approximately 6,500 spaces, of which 4,650 (72 percent) are allocated to monthly permit parking.

Institutional Surface Lots

Table 3 presents a detailed inventory of the study area parking lots controlled by the individual LMA institutions. Shown for each facility are an ID number corresponding to the facility's location on Figure 5, the name of the institution which controls the facility, the facility's street address, the legal (licensed) space capacity and the number of turnover spaces (i.e., those spaces which are allocated to non-monthly parkers). A total of 2,430 surface parking spaces fall into this category. These are owned or controlled by 16 area institutions ranging from Harvard University with nine parking lots and 506 parking spaces to the Bank of New England with one 12-space facility.

MASCO Surface Lots

MASCO operates three surface parking facilities in the study area as listed in Table 4. These have 408 spaces and range in size from 25 to 245 spaces.

Parking Garages

There are 11 parking garages in the study area, including 10 controlled by individual institutions and one by MASCO (Servicenter). These facilities and their locations are listed in Table 5. There are 3,666 spaces in these facilities, by far

TABLE 3
INSTITUTIONAL SURFACE PARKING LOTS IN THE STUDY AREA

ID Number*	Institution	Location	Capacity (spaces)	Turnover Spaces**
1A	Beth Israel Hospital	320-330 Brookline Avenue	20	20
1B		336 Brookline Avenue	116	
1C		340-350 Brookline Avenue	29	
2A	Brigham & Women's Hospital	721 Huntington Avenue	45	45
2B		Shattuck Street	21	
2C		26 Binney Street	45	45
17		221 Longwood Avenue	24	
12F		225 Longwood Avenue	18	
3	Children's Hospital	Blackfan Street	56	56
26		Deaconess Road	30	20
28		283 Longwood Avenue	50	
4	Dana-Farber Cancer Institute	65 Deaconess Road	51	
5	Joslin Diabetes Center	356 Longwood Avenue	48	
6B	New England Deaconess Hosp.	18 Autumn Road	23	
6C		454 Brookline Avenue	86	
8A	Winsor School	214 The Riverway	24	
8B		Pilgrim Road	60	
9	Wheelock College	25 Pilgrim Road	60	
10A	Boston Latin School	78 Avenue Louis Pasteur	53	
10B		78 Avenue Louis Pasteur	60	
11	Boston English School	Avenue Louis Pasteur	25	
12A	Harvard University	29 Shattuck Street	41	
12B		286 Longwood Avenue	14	
12C		659 Huntington Avenue	30	
12D		188 Longwood Avenue	15	
12E		188 Longwood Avenue	21	
12G		200 Longwood Avenue	151	
12H		107 Avenue Louis Pasteur	65	
12I		10 Shattuck Street	19	
55		Blackfan Street	125	
14A	Mass College of Pharmacy	179 Longwood Avenue	117	
14B		179 Longwood Avenue	23	
15A-E	Emmanuel College	400 The Fenway	435	
16A	Simmons College	54 Pilgrim Road	9	
16B		82 Pilgrim Road	16	
16C		Avenue Louis Pasteur	375	
19	Bank of New England	727 Huntington Avenue	12	
25	Roxbury Community College	Palace Road	18	
	Total		2,430	186

---

* See Figure 5.

** Turnover spaces are those available for patients, visitors and others who are not monthly parkers.

TABLE 4
MASCO SURFACE PARKING LOTS IN THE STUDY AREA

ID Number*	Owner	Location	Capacity (spaces)	Turnover Spaces**
22	Mass. College of Art	Palace and Tetlow	25	
13	Mass. College of Art	364 Brookline Avenue	138	58
7	Temple Israel	Plymouth Street	245	
	Total		408	58

* See Figure 5.

** Turnover spaces are those available for patients, visitors and others who are not monthly parkers.

TABLE 5
PARKING GARAGES IN THE STUDY AREA

ID Number*	Institution	Location	Capacity (spaces)	Turnover Spaces**
30	Wheelock College	55 Pilgrim Road	50	
31	Beth Israel Hospital	336 Brookline Avenue	483	318
34	Dana-Farber Cancer Institute	44 Binney Street	244	144
36	Servicenter (MASCO)	488 Brookline Avenue	650	248
33	Children's Hospital	Blackfan Street	429	399
37	Children's Hospital	333 Longwood Avenue	495	188
38	Children's Inn	342 Longwood Avenue	110	35
35	New England Deaconess Hosp.	110 Francis Street	310	160
39	New England Deaconess Hosp.	378 Longwood Avenue	761	116
40	Boston English High School	Avenue Louis Pasteur	116	
41	Overholt Thoracic Clinic	35 Francis Street	18	
	Garage Subtotal		3,666	1,608

* See Figure 5.

** Turnover spaces are those available for patients, visitors and others who are not monthly parkers.

the most prevalent type of parking in the study area. Of these, 1,608 are turnover spaces, which are allocated for short-term use by patients, visitors and others who are not monthly parkers.

- Parking Facilities Outside the Study Area

The parking supply within the study area is clearly inadequate to meet the combined demand for employee and visitor parking. To accommodate some of the excess demand for parking, both MASCO and the individual institutions have either leased or purchased parking facilities outside the study area. Most of these facilities are located in the Kenmore-Fenway area, a few are in the Mission Hill-Roxbury area, and one is located at the Soldiers Field Park housing complex on Western Avenue in Allston. Most of these facilities are served by one of the several MASCO shuttle buses, enabling motorists to park and ride to the LMA.

Table 6 provides a detailed listing of the locations of all parking facilities outside the study area, including surface lots under institutional or MASCO control, and the four garages, with three under institutional and one under MASCO control. In total, there are 1,794 spaces controlled by MASCO and 2,062 spaces controlled by individual institutions, resulting in 3,856 spaces oustide the study area.

3. Pricing

Parking rates set by LMA institutions reflect a need to distinguish between employee parking and customer/visitor parking. For the latter, hourly and daily parking rates are charged, while for the former, monthly permits are available. Table 7 gives a sampling of hourly and daily parking rates, according to information compiled by MASCO in 1986.

TABLE 6
PARKING FACILITIES OUTSIDE THE STUDY AREA

Lot Name	Location	Capacity (spaces)*
MASCO Surface Lots		
Kenmore/Red Sox	71-99 Brookline Avenue	277
Fenmore Realty	35 Overland Street	90
Mattes Management	6 Maitland Street	42
Fenway Auto	1325 Boylston Street	40
Mass. Tire Corp.	1320 Boylston Street	115
Laz Parking Lot	189 Ipswich Street	85
Wentworth	80 Prentiss Street	380
Mass. College of Art	670 Huntington Avenue	295
Private	130 Peterborough Street	80
Salvation Army	61 Brookline Avenue	40
		1,444
Institutional Surface Lots		
Mass. Mental Health Center	74 Fenwood Road	76
Mass. Mental Health Center	Vining Street	36
Children's Hospital	Wentworth Institute	211
Children's Hospital	819 Beacon Street	170
New England Deaconess Hospital	33 Jersey Street (Sears)	80
		573
Garages		
Mission Park Garage (Brigham & Women's Hospital)		1,362
91-101 Queensberry Street (Beth Israel Hospital)		46
59-75 Queensberry Street (Beth Israel Hospital)		81
Western Avenue (MASCO)		350
		1,839
Total		3,856

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* Capacity listed is the number of spaces controlled by MASCO or by an LMA institution. Total capacity is greater at some sites.

TABLE 7
HOURLY AND DAILY PARKING RATES

Parking Duration (Hours)	Lowest Rate	Median Rate	Highest Rate
1-2	$3.00	$3.00	$4.00
3-4	$5.00	$5.00	$7.50
5-6	$7.00	$10.00	$12.00
6-24	$10.00	$12.00	$15.00

Monthly permits for employees are available, at various subsidy levels, at facilities within and outside of the study area. Since institutions must compete for qualified staff with suburban medical and educational institutions who offer free or inexpensive parking, subsidized parking is often used as an employee benefit for recruitment and retention of certain categories of employees. Institutions and MASCO each control certain facilities and each organization sets its parking pricing policies according to its individual needs and objectives. The monthly parking rates at each facility depend on a variety of factors including the amount of the lease payments (if any) for that facility, the cost of providing shuttle service (if any), the types of employees assigned to the facility, and the policies of the organization which controls the facility.

In discussing the prices of employee parking, it is important to distinguish between remote parking facilities and close-in spaces. For this analysis, close-in spaces are defined as including all employee spaces inside the study area as well as the five facilities (numbered 27A, 27B, 27C, 32 and 49 on Figure 5) which are less than 400 feet from the study area. Remote spaces are defined to include all employee spaces in facilities located more than 400 feet from the study area.

Remote parking facilities tend to be under long- or short-term lease, rather than owned, and the costs of shuttle services as well as the lease payments are rolled into the charge for a monthly parking space. As a result, the average cost to institutions of remote parking spaces is $70 per month. However, employees who park at remote parking facilities pay an average of only $37 per month, with the difference subsidized by their employers.

By comparison, the average price paid by employees who park in close-in spaces is approximately $52 per month. When only those spaces controlled by MASCO or one of the hospitals are considered, the average price is about $63 per month. Table 8 presents the monthly prices divided by 21 work days per month to reflect an average daily price of monthly parking.

TABLE 8
AVERAGE DAILY USER COST FOR MONTHLY PARKING*

	Close-In Spaces**		Remote Spaces	
	Percentage	Cumulative Percentage	Percentage	Cumulative Percentage
No Charge	13%	13%	0%	0%
$.01 - $.99	14%	27%	0%	0%
$1 - $1.99	4%	31%	63%	63%
$2 - $2.99	29%	60%	35%	98%
$3 - $3.99	24%	84%	2%	100%
$4 - $4.99	13%	97%	0%	100%
$5 - $5.99	3%	100%	0%	100%

* Monthly price divided by average of 21 workdays per month.

** Includes all off-street spaces in the study area, including those controlled by non-members of MASCO, and also includes parking facilities less than 400 feet outside the study area.

4. Summary

There are 70 off-street parking facilities included in this analysis. Based on the most recent data available, there are 7,715 spaces within the study area, including 1,090 on public streets and 6,625 on private property. The individual categories of parking are summarized in Table 9. When all facilities are included, the total inventory is 11,571 spaces.

Hourly and daily parking prices in the study area are comparable to those found in Boston's Central Business District (CBD). These rates typically fall between one and two dollars per hour for both short-term and all-day parking. LMA employees, on the other hand, pay much less for parking than CBD employees pay. While most CBD employess pay between $100 and $200 per month, LMA employees, on average, pay about $52 per month at close-in facilities and $37 per month at remote facilities. The employee parking subsidies provided by LMA employees are motivated by their need to compete for qualified staff with suburban employers who offer free parking.

TABLE 9
PARKING SUPPLY SUMMARY

Facility Type	Number of Facilities	Number of Spaces
Inside the Study Area		
Surface Lots	41	2,838
Garages	11	3,666
Public Streets*	--	1,090
Private Ways	--	121
Subtotal	52	7,715
Outside the Study Area		
Surface Lots	14	2,017
Garages	4	1,839
Subtotal	18	3,856
Total	70	11,571

* Includes 210 resident permit spaces, 455 metered spaces, and 425 unmetered spaces with posted time limit restrictions.

III. Existing Transportation System

III. EXISTING TRANSPORTATION SYSTEM

The land use activity within the LMA is supported by a system of transportation which includes public and private roadways, public transportation including bus and light rail transit service, specialized privately supported transportation services, and a network of pedestrian walkways. Each of these components of the overall transportation system provides the LMA with internal circulation and with access from all geographical directions within the Boston metropolitan area. The basic characteristics of this transportation system are outlined below.

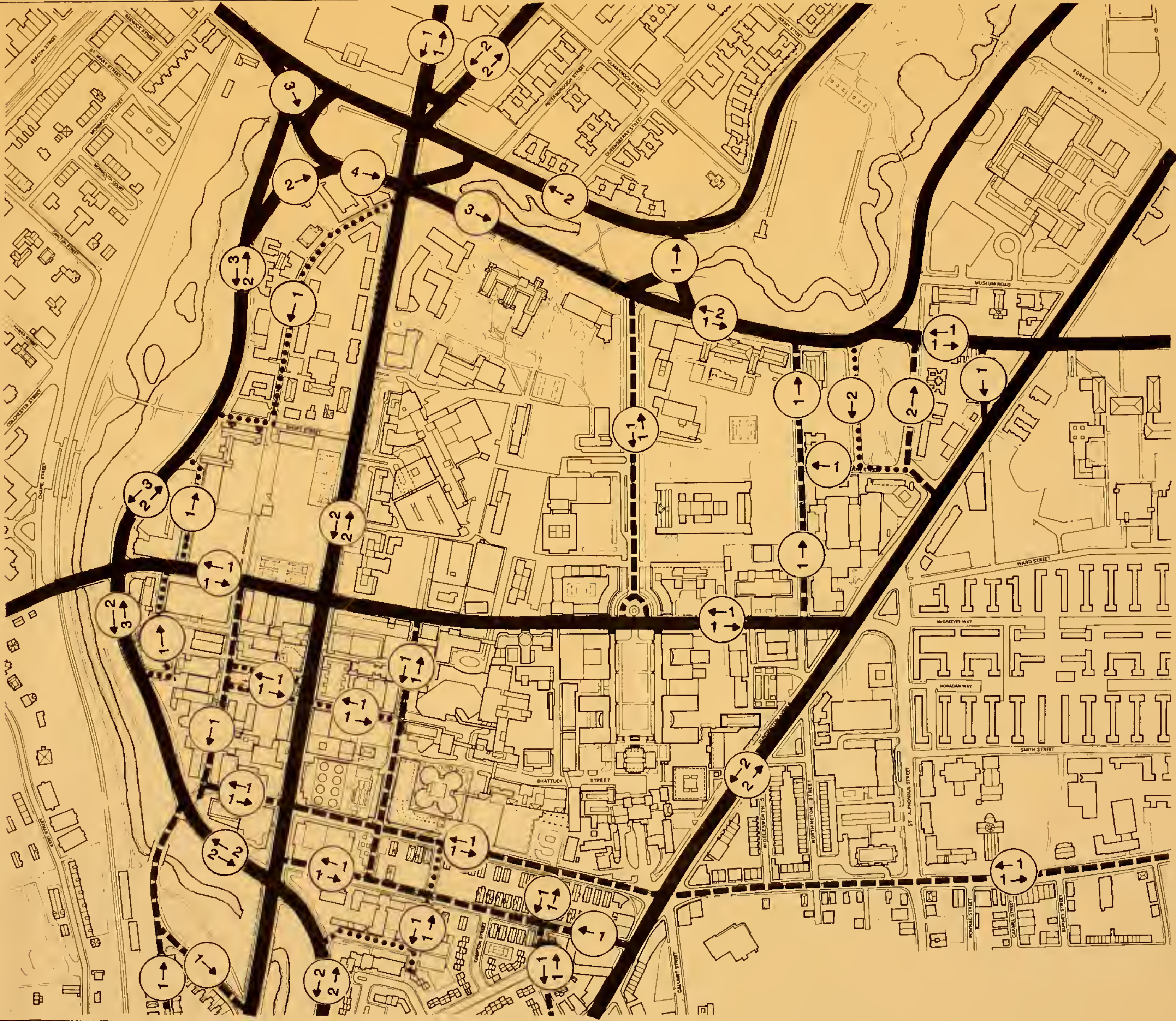
A. FUNCTIONAL ROADWAY CLASSIFICATION

The first step in understanding the existing network of streets and roads within the LMA is to define the functional characteristics of the roadways and their relationship to area land use. Classifying roadways is important in order to define the type of traffic using the roadways in terms of volume, average trip length and continuity of the system. These characteristics together define a hierarchy of roadway purpose: to service a small localized area or to service a larger citywide or regional traffic market.

Historically, four general classifications of roadway function have been used by traffic planners: expressways, arterials, collectors and local streets. Table 10 compares the criteria of each of these urban roadway system classifications.

For the LMA, only the arterial, collector and local functional classifications are appropriate to define the system of roadways. Figure 6 shows this overall classification system, including directional flow and number of continuous lanes of operation along each roadway.

Existing Traffic Circulation Pattern & Functional Roadway Classification



LEGEND:

▬ **ARTERIALS** (Through Movement & Some Land Access)

▬ ▬ ▬ **COLLECTOR** (Through Movement & Land Access)

•••••• **LOCAL** (Land Access)

⇄ Number of Travel Lanes by Direction

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Fig. 6

TABLE 10
URBAN ROADWAY SYSTEM FUNCTIONAL CLASSIFICATION

Classification	Principal Service Function	Typical Trip Length	Land use Linked by the Facility
Expressway	Through movement	3 miles	Downtown and major generators
Arterial	Through movement and some land access	1 mile	Downtown and secondary generators
Collector	Through movement and land access	1 mile	Local areas
Local	Land access	1/2 mile	Individual land sites

Of the arterial roadways, Huntington Avenue, Brookline Avenue and the Riverway all provide bi-directional and generally northeast to southwest traffic movements, with Huntington Avenue having a light-rail line dividing the directional lanes in a shared right-of-way operation. Longwood Avenue, also bi-directional, and the Fenway and Park Drive (a one-way pair) generally provide east-to-west traffic movements through the area. Both the Fenway and Park Drive intersect Brookline Avenue at adjacent intersections, with roadway loops provided to reverse direction. The Fenway, Park Drive, Brookline Avenue, and the Riverway essentially operate as an extended rotary with all traffic flowing in a counterclockwise direction.

Each of the collector roadways (Francis Street, Fenwood Road, Binney Street, part of Pilgrim Road, Avenue Louis Pasteur, Palace Road, and a portion of Evans Way) provides for traffic movement to the more regionally oriented, higher-capacity arterials described above. One of their principal functions is to provide direct access to land uses, particularly parking garages.

Finally, the LMA local roadways include the remainder of Pilgrim Road and Evans Way, Tetlow Street, Deaconess Road, Joslin Place, Autumn Street, Short Street, Vining Street, St. Albans Road and Plymouth Street. The principal function of these local streets is to provide direct access to abutting land uses.

Traffic operation of the system of LMA roadways is, to a large extent, controlled by the operation of the traffic signals and the degree to which the traffic can be accommodated within the capacity of the intersections. Key signalized intersections within the LMA include Brookline/Longwood, Brookline/Riverway, Brookline/ Fenway, Longwood/Riverway and Longwood/Huntington Avenue. These intersections represent locations where arterials meet and where traffic volumes are highest. At present, only the segment of Brookline Avenue within the study area is under controlled signal timing progression, which attempts to maximize the efficiency with which traffic is processed along Brookline Avenue. Traffic volumes and levels of service are presented in Chapters IV and V, respectively.

B. EXISTING PUBLIC TRANSPORTATION

Improvements to public transportation service and ridership are a potential solution to help address traffic problems in the LMA. To develop recommendations related to transit service and ridership, it is necessary to document the quantity and quality of the services currently provided and the current utilization level of each service. Where service quality is poor, recommendations must focus on service improvements. Where service is good but ridership is low, consideration should be given to providing incentives to shift drivers to mass transit.

In a typical central business district, peak hour service is by and large the only important consideration. In the LMA, on

the other hand, many different work shifts exist. Mid-afternoon service is important to second-shift workers arriving at 2:45 PM and first-shift workers departing after 3:00 PM as well as for visitors to medical facilities. Late evening service is essential for both second-shift and third-shift workers, and weekend service is essential for workers with Saturday or Sunday hours. A lack of quality service in the late evening (after 9:00 PM) will increase daytime traffic because a worker who needs a car for one of the two daily work trips will have to use a car for both. Even a lack of quality weekend service in the LMA may indirectly increase weekday rush hour traffic in the LMA by increasing the propensity of LMA workers who work weekends and weekdays to use an automobile for all trips to and from the LMA.

The Longwood Medical Area (LMA) is served by two branches of the MBTA Green Line and four regular MBTA bus routes. Routes and estimated ridership are listed in Table 11 and discussed below. MBTA transit routes as well as two bus routes operated by MetroBus, a subsidiary of MASCO, are shown in Figure 7. Each of these routes provide service to communities outside the LMA. For medical area day-shift workers and students who live within walking distance of any of these MBTA routes, mass transit is an alternative for commuting trips. Deficiencies which discourage use of mass transit are discussed in Chapter V.

Each branch of the Green Line connects a part of the LMA with the Back Bay and downtown Boston, where connections to other subway lines can be made. The Highland Branch, or Riverside (D) Line, serving Longwood Station at the western fringe of the LMA, runs west through Brookline and Newton to Riverside Station (near the junction of Routes I-90 and I-95), where park-and-ride facilities are provided. The Arborway (E) Line, serving Huntington Avenue along the eastern border of the LMA, runs south through Roxbury and Jamaica Plain to Forest Hills Station, where

TABLE 11
MBTA SERVICE SUMMARY

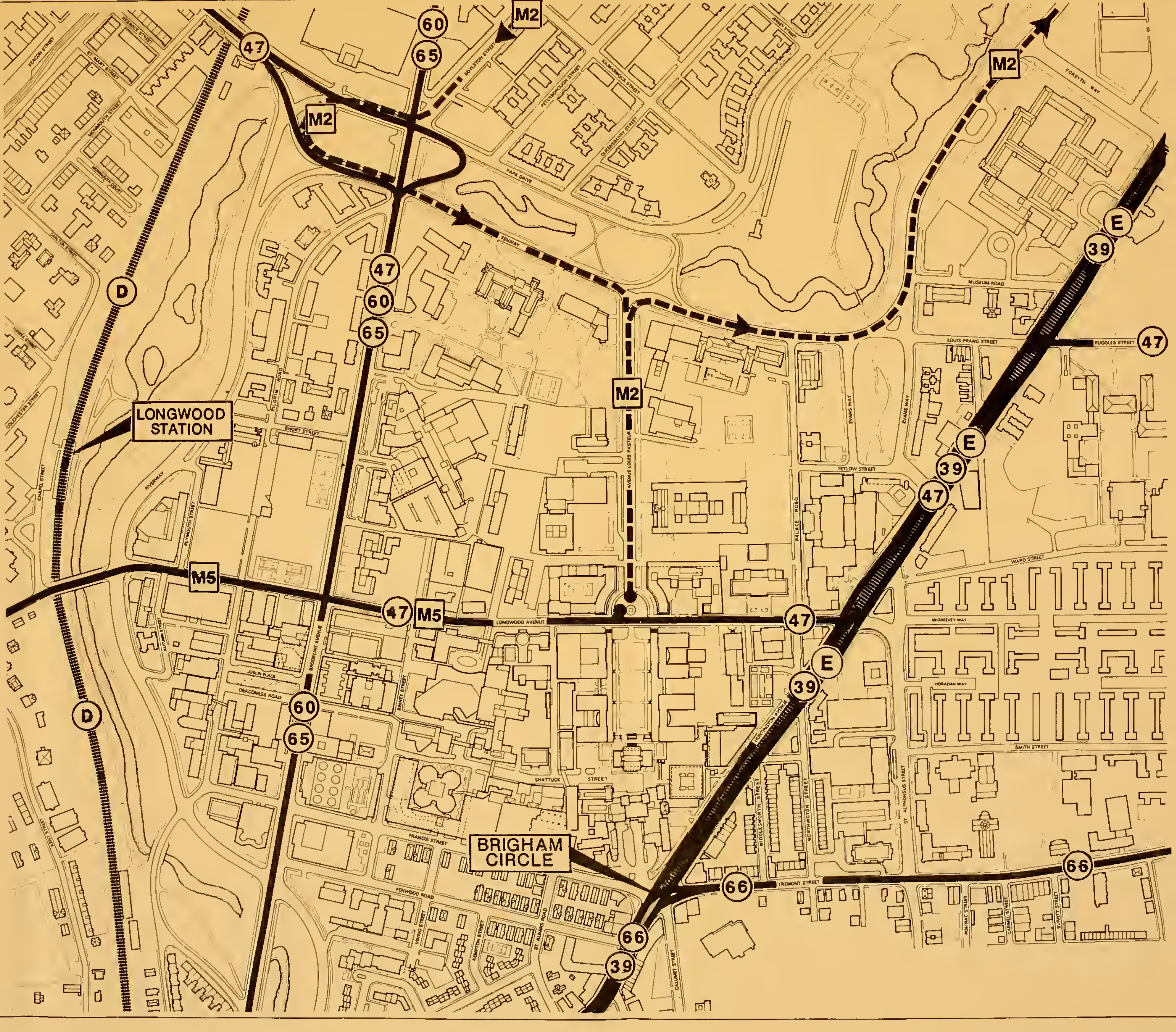
Route	Segment	Frequency						Estimated LMA Riders*
		AM Peak	Midday	PM Peak	Evening	Sat.	Sun.	
Light Rail Lines								
E/39	Downtown	**	**	**	**	**	**	1,650
E/39	Jamaica Plain	**	**	**	**	**	**	800
D	Downtown	**	**	**	**	**	**	350
D	Brookline/Newton	**	**	**	**	**	**	525
Bus Routes								
47	Roxbury	**	20	10	25	20	40	650
65	Brookline/Brighton	20	30	25	None	30	None	300
47	Cambridge	20	20	20	25	20	40	235
66	Brookline/Allston	**	14	**	30	13	30	180
60	Brookline/Newton	17	30	18	30	30	60	125
66	Roxbury	**	14	**	30	13	30	50
60/65	Kenmore	2-12***	15	3-18***	30	15	60	85
TOTAL								4,950

* Estimate of people arriving in the LMA on weekdays between 6:00 AM and 9:15 AM, based on MBTA data and observations made as part of this study.

** Service is scheduled every ten minutes or more frequently.

*** Time between successive buses varies widely because the schedules of the two overlapping routes are not coordinated with each other during peak hours.

Source: MBTA Schedules.



Transit Routes Serving Communities Outside The LMA

LEGEND:

○	MBTA Route
□	MASCO Bus Route
—	Existing Routing
- - -	Planned Routing
▥	Light Rail Line
D	Riverside–Downtown
E	Brigham Circle–Downtown
39	Copley Square–Forest Hills
47	Central Square–Andrew Square
60	Kenmore Square–Chestnut Hill
65	Kenmore Square–Brighton Center
66	Allston–Dudley
M2	Cambridge–LMA (Planned Rerouting)
M5	Brookline/Allston–LMA

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Fig. 7

passengers may transfer to buses serving Dedham, West Roxbury, Hyde Park and Roslindale. Both branches operate seven days a week, from 5:30 AM until after midnight. Service is scheduled at least every 10 minutes during most of those hours.

Due to ongoing road construction on Huntington Avenue in the LMA, Arborway streetcar service south of Brigham Circle is suspended, and a temporary bus route (#39) runs along the trolley route between Forest Hills Station in Jamaica Plain and Copley Square in the Back Bay. Buses provide the same service hours as the Green Line streetcars did, but with higher frequencies. Buses are scheduled at least every five minutes each weekday from 6:30 AM to 11:00 PM. In addition, light rail vehicles (LRVs) operate in the Huntington Avenue median between Brigham Circle in the LMA and downtown Boston.

Bus Routes 47 and 66 both travel east to Dudley Square and other points in Roxbury. Route 66 serves the LMA chiefly at Brigham Circle, while Route 47 provides more comprehensive coverage of the LMA, serving much of Longwood and Brookline Avenues. Route 66 also runs northwest through Brookline to Allston, while Route 47 travels north through Cambridgeport to Central Square. At Ruggles Station, Route 47 connects with the Orange Line and many Roxbury and Dorchester bus routes. Route 47 was recently extended eastward to meet the Red Line at Andrew Square.

Routes 47 and 66 have similar service hours and frequencies: headways are 10 minutes or less during rush hours, about 20 minutes at midday, and about 30 minutes during evenings and weekends. These routes can be used for commuting by second-shift and third-shift workers because service runs past midnight seven days a week. However, the low frequencies make evening travel inconvenient.

MBTA Routes 60 and 65 parallel each other as both run the full length of Brookline Avenue between Kenmore Square and Washington Street (designated as State Highway Route 9) in Brookline Village. From there, Route 60 detours through a residential section before following Route 9 to Chestnut Hill in Newton. Route 65 turns to the northwest, following Washington Street through Brookline to Brighton Center.

Routes 60 and 65 provide less frequent service than Routes 47 and 66. Headways on Routes 60 and 65 are about 20 minutes during rush hours, about 30 minutes at midday, and about 30 minutes on Saturdays. Route 60 runs hourly on Sundays and half-hourly on weekday evenings, while Route 65 provides no evening or Sunday service and thus is not an option for second-shift and third-shift workers.

Ridership data and service quality are discussed in Chapters IV and V, respectively.

C. OTHER TRANSPORTATION SERVICES

1. MASCO Bus Routes

MetroBus, a subsidiary of MASCO, operates four bus routes, which are described in Table 12. Routes M2 and M5 (shown earlier in Figure 7) provide fixed-route service to communities and neighborhoods outside the LMA, carrying persons affiliated with Medical Area institutions between the LMA and their home neighborhoods. Route M2, which serves Harvard Square and other Cambridge points along Massachusetts Avenue, is unique in that it is not limited to rush hours. Route M2 operates every 10 minutes at rush hour, every 20 to 30 minutes at midday, and every hour at night and on Saturdays. Route M5, which serves parts of Brookline and Allston, runs every 17 to 34 minutes in the morning

TABLE 12
MASCO BUS SERVICE SUMMARY

Route	Areas Served	Frequency (Minutes)					Estimated Ridership***
		AM Peak	Midday*	PM Peak	Night**	Saturday	
M1	Fenway/Kenmore Area Parking	8	20-30+	8	None	None	825
M2	Cambridge	10	20-30	10	60	60	825
M2	Brookline	17-34++	None	30++	120	3 trips	0++
M4	Prentiss Street Parking	8	None	10-15	None	None	550
M5	Western Avenue Parking	17	None	30	None	None	35
M5	Allston/Brookline	17-34	None	30	None	None	65
Total							2,300

* Free taxicab service to satellite parking facilities is provided at midday in emergency situations.
** Night service is that provided after 8:30 PM.
*** Weekday riders arriving in the LMA between 6:00 AM and 9:15 AM.
+ Midday service to this area is actually provided by Route M2 buses.
++ Peak hour service to this area is actually provided by Route M5 buses.
Source: MASCO

peak period (6:15 to 9:30 AM) and every 30 minutes in the afternoon peak period (2:45 to 7:15 PM).

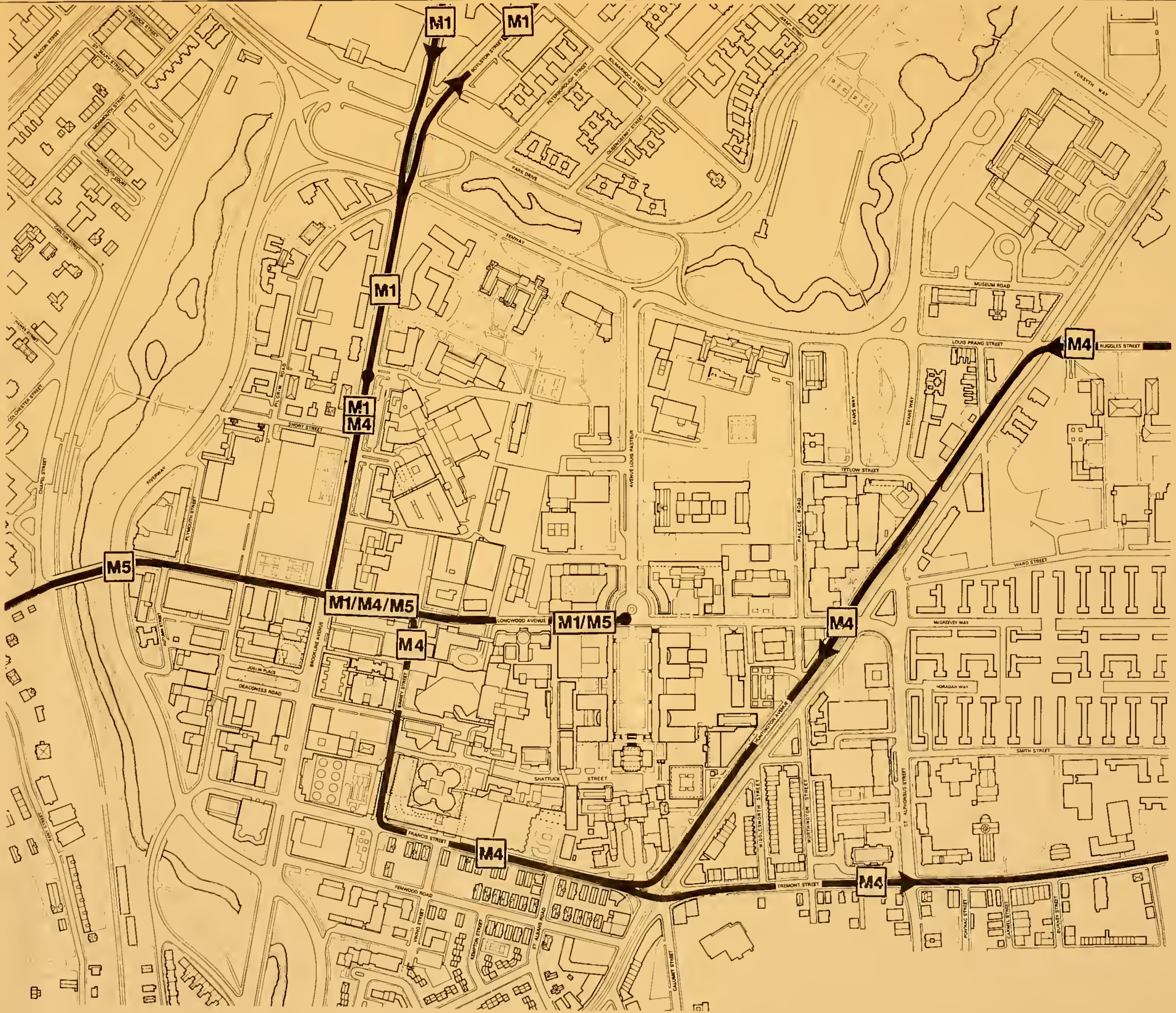
Three MASCO routes (see Figure 8) connect the LMA with satellite parking facilities. Route M1 serves a cluster of parking areas north of the LMA near Kenmore Square and Fenway Park. It runs every eight minutes during both rush hours, but provides no service at other times. At midday, however, the Route M2 (Cambridge) buses, which run every 20 to 30 minutes, detour through Kenmore Square to fill the gap between the rush hours. In addition, all satellite parking patrons requiring emergency transportation to their cars are given free taxicab service.

Route M4 serves a satellite parking lot east of the LMA on Prentiss Street near Parker Street. Route M4 operates at 8-minute headways in the morning rush hour and 10- to 15-minute intervals in the afternoon rush hour. Route M5, which serves Brookline and Allston, as mentioned earlier, also serves MASCO's Western Avenue remote parking facility near the Allston-Cambridge exit of the Massachusetts Turnpike. Buses serving this parking facility run every 17 minutes in the morning rush hour and every 30 minutes in the afternoon rush hour. Four of the 13 morning bus trips operate non-stop via the Turnpike, while all other trips operate on the local street system.

2. Private Carriers

Marathon Line offers hourly bus service between Huntington Avenue points and Worcester, with many intermediate stops along Route 9, including Shoppers World in Framingham. The Framingham fare is $2.50 each way, and an 11-ride ticket costs $25.00. Several taxicab companies also serve the LMA.

MASCO Bus Routes Serving Parking Facilities



LEGEND:

M1 Fenway/Kenmore Area Parking
M4 Prentiss Street/Parker Street Area Parking
M5 Western Avenue Parking

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Fig. 8

3. Ridesharing Services

MASCO, in cooperation with the state-funded CARAVAN program, offers computerized carpool/vanpool matching service for LMA employees. Vanpools receive free parking at the Servicenter Garage on Francis Street.

D. PEDESTRIAN NETWORK

The LMA pedestrian network consists of sidewalks on both sides of most streets, crosswalks, several pedestrian ways along streets that are closed to traffic, some tunnels under streets, and a few enclosed overhead pedestrian passageways connecting buildings on opposite sides of the street. In 1984, MASCO commissioned a study[2] of a possible new system of overhead passageways, known as the Pedestrian Connector. The study estimated that between 5,000 and 11,000 walking trips would occur on the proposed system during a typical 8-hour work day.

2/ Payette Associates, "Pedestrian Connector," 1984.

IV. Area Travel Patterns

IV. AREA TRAVEL PATTERNS

Information on travel patterns in the Longwood Medical Area was gathered from several sources. The principal data sources used in this chapter are a survey of LMA institutions undertaken by MASCO in 1987; an interview survey of automobile users conducted by VHB in May, 1987; mechanical and manual traffic volume counts directed by VHB, MASCO and others; public transportation and shuttle bus ridership figures provided by the MBTA and MetroBus; and U.S. Census data summarized by the Central Transportation Planning Staff.

A. Journey-to-Work Data from the 1980 U.S. Census

The 1980 U.S. Census gathered information on where people live and work, and how they travel between home and work. The Commonwealth's Central Transportation Planning Staff (CTPS) provides summaries of U.S. Census data by traffic zone. Zone 97 and 108 together contain the entire Longwood Medical Area and just a small amount of land outside the LMA. Since the vast majority of workers employed within these two zones work inside the LMA, the journey-to-work data for the two zones combined are a good approximation of LMA work-trip patterns (as of 1980). Zone 108 contains the portion of the LMA south of Longwood Avenue, including all the LMA medical institutions except the Beth Israel Hospital. It also contains some neighborhood-oriented businesses near Brigham Circle. Zone 97 contains the balance of the LMA, including all of the LMA educational institutions except the Harvard schools. It also contains the Museum of Fine Arts and the Wentworth Institute.

Excluding a handful of people who work at home and thus do not travel to work, about 28,300 people work in the two zones combined; 68 percent of these work south of Longwood Avenue in

Zone 108. As shown in Table 13, 82 percent of all work trips in the two zones combined are by motorized vehicle; the remaining 18 percent are by bicycle or on foot. The vehicular work trips are about one-third transit (including taxi) and two-thirds private auto. Solo drivers represent 40 percent of all commuters, 48 percent of vehicular work trips, and 71 percent of all automobile commuters. The average occupancy of automobiles commuting to these two zones in 1980 was 1.2; the figure rises to 2.3 when solo drivers are excluded from the calculation.

From the census data, one can also derive the geographic distribution of work trips, the modal split in each geographical area, and the geographic distribution of trips by a given transportation mode or set of modes. As shown in the far right column of Table 14, 41 percent of vehicular work trips to the LMA come from residences in the City of Boston, and a total of 63 percent comes from just six communities including Boston. Because the transit mode share for these six communities is relatively high (42 percent), the six account for 83 percent of all transit work trips but only 54 percent of all automobile work trips to the LMA. Cambridge stands out with the highest transit mode share: 56 percent. MASCO's Bus Route M2, connecting Cambridge with the LMA and carrying Harvard Medical School employees at no fare, may be the key factor behind this result. Outside the six communities listed in Table 14, the transit mode share is only 15 percent.

B. TRIP DATA FROM THE 1987 MASCO SURVEY OF INSTITUTIONS

Figures 9, 10, and 11 describe the temporal distribution on a typical weekday of work trips to and from the six medical institutions in the LMA. The information was compiled from surveys submitted to MASCO by the Beth Israel, Brigham & Women's, Children's, and Deaconess Hospitals, the Dana-Farber Cancer

TABLE 13
MODE SPLIT FOR WORK TRIPS IN OR NEAR THE LMA

	Drive Alone*	Carpool**	Transit***	Taxi	Bicycle	Walk	Total
All Work Trips^							
Zone 97	3,578	1,325	2,039	55	141	1,926	9,066
Zone 108	7,639	3,173	5,251	52	260	2,823	19,212
Total	11,217	4,498	7,290	107	401	4,749	28,278
All Work Trips (%)^							
Zone 97	39	14.6	23	0.6	1.6	21.2	100
Zone 108	40	16.5	27	0.3	1.4	14.7	100
Composite	40	15.9	26	0.4	1.4	16.8	100
All Vehicular Work Trips (%)^^							
Zone 97	51	18.9	29	0.8	--	--	100
Zone 108	47	19.7	33	0.3	--	--	100
Composite	48	19.4	32	0.5	--	--	100

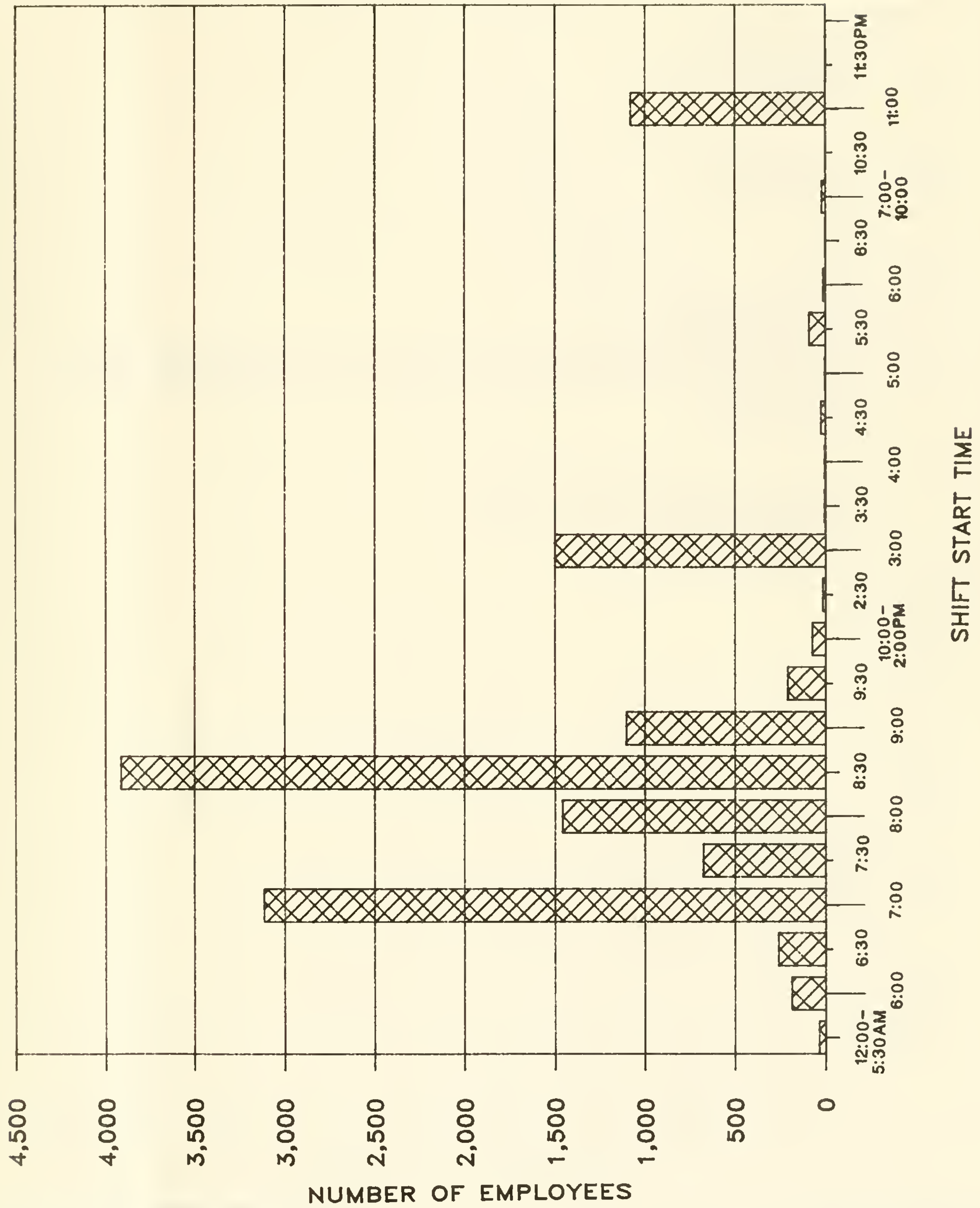
* Includes motorcycles.
** Automobile with 2 or more persons. Average occupancy of work-trip carpools is 2.3.
*** Bus, streetcar, subway, elevated, or commuter rail.
^ Excludes work at home.
^^ Excludes work at home, walk, bicycle, other modes.
Source: U.S. Census

TABLE 14
VEHICULAR WORK TRIP DISTRIBUTION*

Residence Location	Auto Work Trips			Transit Work Trips			All Vehicular Work Trips		
	Number	% of Row	% of Column	Number	% of Row	% of Column	Number	% of Row	% of Column
Boston	5,386	57	34	4,008	43	54	9,394	100	41
Brookline	968	60	6	648	40	9	1,616	100	7
Newton	981	67	6	487	33	7	1,468	100	6
Cambridge	466	44	3	603	56	8	1,069	100	5
Somerville	342	62	2	211	38	3	553	100	2
Quincy	324	68	2	149	32	2	473	100	2
Subtotal	8,467	58	54	6,106	42	83	14,573	100	63
Other Places	7,262	85	46	1,289	15	17	8,551	100	37
TOTAL	15,729	68	100	7,395	32	100	23,124	100	100

* Worksites in CTPS Zones 97 and 108.

Source: U.S. Census



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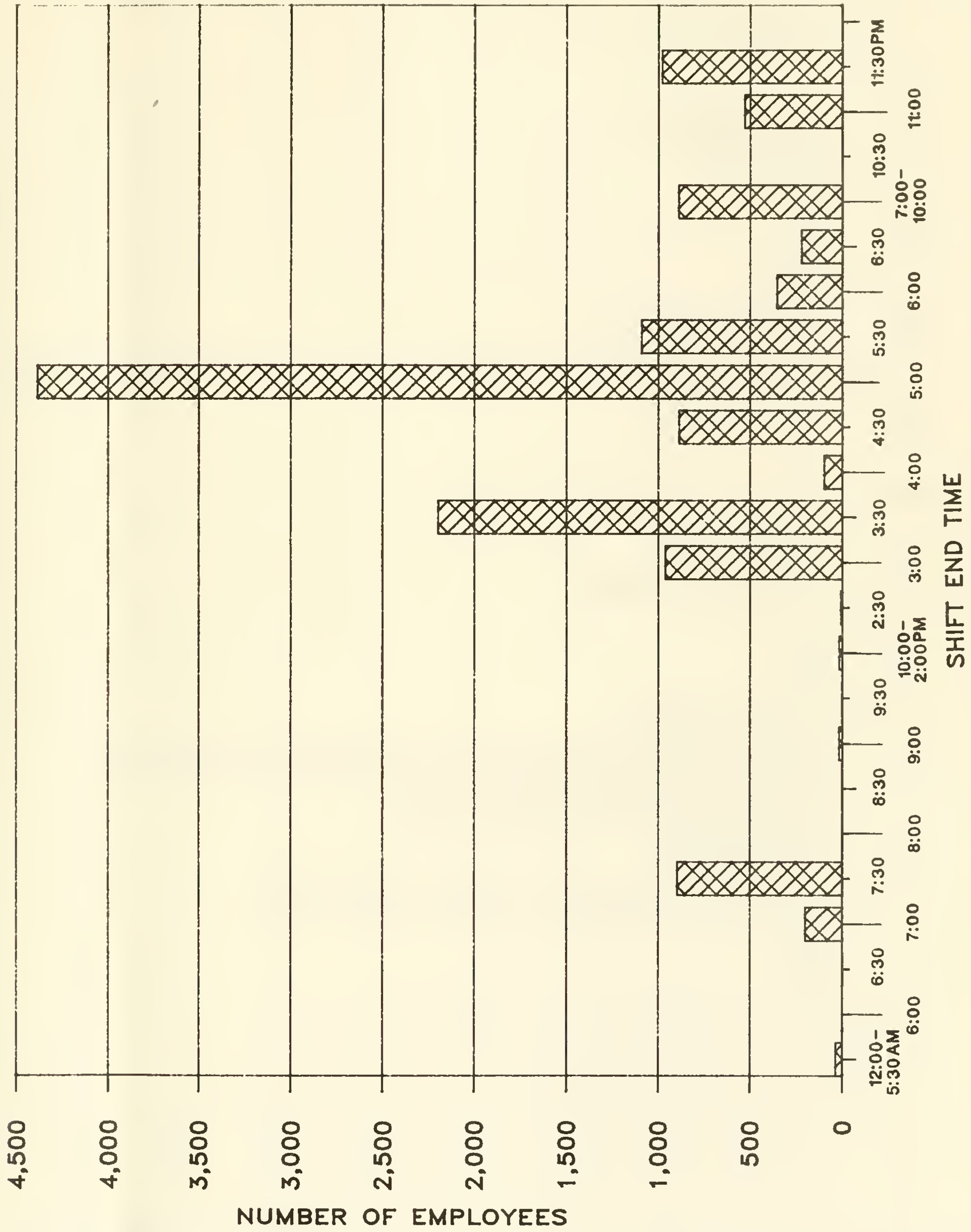
Number of Employees by Shift Start Time

SOURCE: Composite of data supplied by Brigham & Women's Hospital, Beth Israel Hospital, New England Deaconess Hospital, Children's Hospital Medical Center, Dana-Farber Cancer Institute, and Joslin Diabetes Center

Fig. 9



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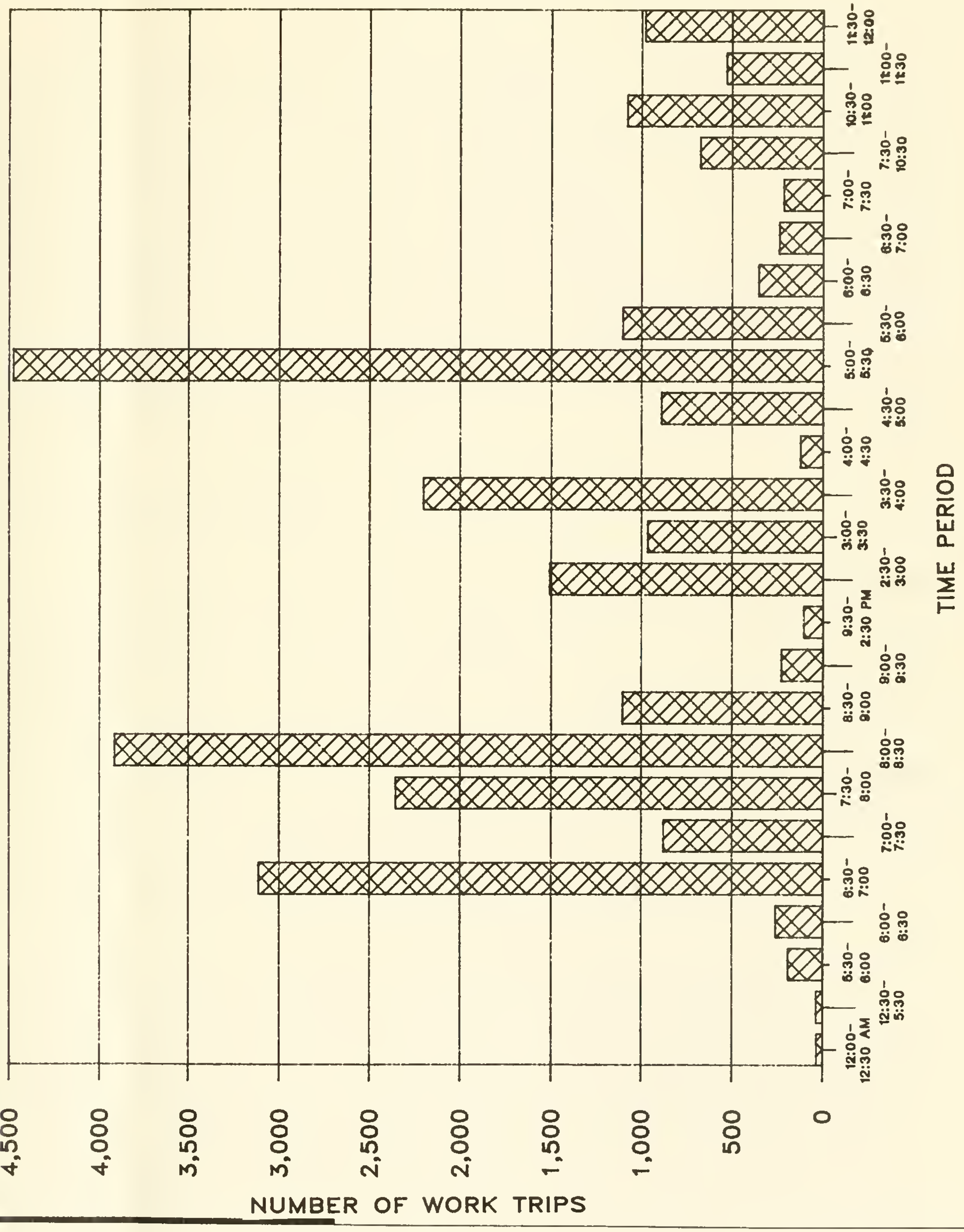
Number of Employees by Shift End Time

SOURCE: Composite of data supplied by Brigham & Women's Hospital, Beth Israel Hospital, New England Deaconess Hospital, Children's Hospital Medical Center, Dana-Farber Cancer Institute, and Joslin Diabetes Center

Fig. 10



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SOURCE: Composite of data supplied by Brigham & Women's Hospital, Beth Israel Hospital, New England Deaconess Hospital, Children's Hospital Medical Center, Dana-Farber Cancer Institute, and Joslin Diabetes Center

Work Trips by Time Period

Fig. 11

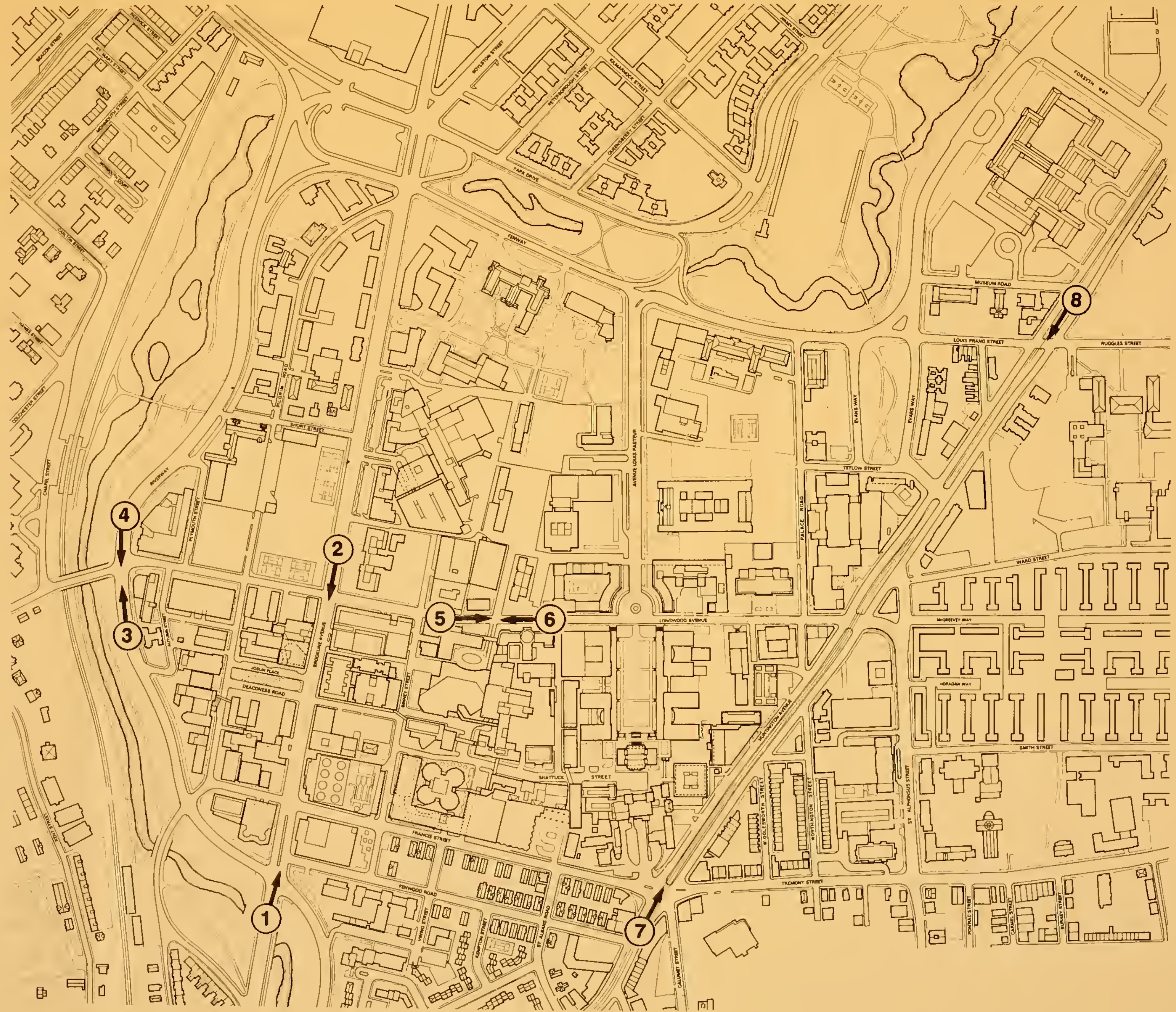
Institute, and the Joslin Diabetes Center. The information is limited to the medical institutions because not all educational employers were able to provide MASCO with employee data by shift. Still, the information is very illustrative of the prevalence of 8:30 AM to 5:00 PM workers. In all, almost 14,000 entering work trips and almost 14,000 exiting work trips are represented. The first two figures give the temporal distribution of shift start times and shift end times, respectively. The final graph provides for each time period the sum of employees arriving and departing during that half-hour.

C. 1987 AUTO USER SURVEY

An intensive data collection effort was performed during May of this year by VHB in order to obtain information regarding the origins, destinations, trip purposes and vehicle occupancy rates of traffic using the LMA roadways. The approach was an automobile user survey at eight signalized intersections along LMA arterials, shown in Figure 12. The survey was conducted between 7:00 AM and 9:00 AM, and between 3:30 PM and 5:30 PM. The survey procedures also included simultaneous counting of the total number of vehicles by lane during the survey periods.

The resultant data were combined in order to expand the survey sample data to the total number of trips at these locations for each time period. Table 15 shows the survey locations, number of surveys for each time period, and number of vehicles counted and represented by this sample. Overall, 1,863 valid surveys representing 23,800 vehicles were collected across the eight stations.

Auto User Survey Locations



LEGEND:

ⓧ Station Number
→ Direction of Travel

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0 250 500
SCALE IN FEET

Fig. 12

TABLE 15
SUMMARY OF VEHICLES SURVEYED BY LOCATION

	AM		PM	
Location	Surveys	Vehicles	Surveys	Vehicles
Brookline Avenue NB south of the Riverway	177	1,542	150	1,103
Brookline Avenue SB north of Longwood Ave.	95	1,405	128	1,984
Riverway NB south of Longwood Ave.	152	2,847	129	2,160
Riverway SB north of Longwood Ave.	155	1,618	191	2,795
Longwood Ave. EB west of Binney St.	61	987	26	400
Longwood Ave. WB east of Binney St.	38	669	24	352
Huntington Ave. NB south of Francis St.	147	1,608	157	1,240
Huntington Ave. SB north of Ruggles St.	120	1,155	116	1,961
Totals	945	11,831	921	11,995

The results showed that LMA arterials serve a wide geographical area, with more than 180 distinct places (cities, towns and Boston neighborhoods) reported as origins or destinations. Confirming the importance of LMA arterials to the regional travel market was a finding that 65 percent of the total traffic across all stations and time periods did not involve a trip to or from the LMA. The percentage of through traffic varied significantly by station and by time period as shown in Table 16.

TABLE 16
PERCENTAGE OF THROUGH TRAFFIC BY LOCATION

	AM Period		PM Period	
	% LMA	% Through	% LMA	% Through
Brookline Avenue NB South of The Riverway	63	37	40	59
Brookline Avenue SB North of Longwood Ave.	65	35	37	63
Riverway NB South of Longwood Ave.	16	84	21	79
Riverway SB North of Longwood Ave.	19	81	16	84
Longwood EB West of Blackfan Street	82	18	42	58
Longwood WB East of Blackfan Street	72	28	63	37
Huntington Avenue NB South of Francis Street	19	81	26	74
Huntington Avenue SB North of Louis Prang Street	45	55	43	57
TOTAL	40	60	30	70

Both the Riverway and Huntington Avenue exhibited the highest percentages of through traffic represented in the survey. The Riverway, in particular, consistently showed very high northbound and southbound through traffic percentages for the AM peak (83% and 81% respectively) and for the PM peak (79% and 84%). On Huntington Avenue, the major factor influencing the percentage of through traffic was the station location. The segment just south of Brigham Circle, where northbound traffic was surveyed, is not part of a major route to or from the LMA. Through traffic percentages here are understandably high (81% and 74% in the AM

and PM, respectively), especially in the morning, when heavy commuter traffic flows into Downtown Boston. In contrast, the segment just north of Louis Prang Street, where southbound traffic was surveyed, is part of a major route into the LMA. Hence, through traffic percentages here are more moderate (55% and 57% in the AM and PM, respectively).

The results for the Brookline Avenue northbound and southbound stations show the percentages of through traffic for the AM period (37% and 35% respectively) and for the PM period (59% and 63% respectively) to be significantly different. The most likely explanation is that the Brookline Avenue survey stations were in a sense entry gates to the LMA. Surveyors at those stations were therefore likely to interview LMA workers when they arrived in the morning rather than when they departed in the afternoon.

Longwood Avenue showed the lowest percentage of through traffic, particularly during the AM period for both eastbound and westbound directions (18% and 28% respectively). For the PM period a smaller sample was achieved with varying differences for the eastbound and westbound percentage through traffic (58% and 37% respectively) when compared with the morning. The high percentage of eastbound through movement during the afternoon may indicate overall peaking congestion throughout the area, with a greater tendency for cut-through traffic along Longwood Avenue.

The trip purposes of automobile users on LMA arterials are presented in Table 17, which shows that the majority (59%) of auto users during the hours surveyed were commuting to work, and another 10 percent of trips were business related. Trips for classes (9%), medical appointments (7%), and medical visitation (2%) together comprised only 18 percent of auto trips. Since the survey was conducted during peak commuter hours, the high percentage of commuter traffic was expected.

TABLE 17
TRIP PURPOSES OF AUTO USERS

Trip Purpose	% of Total
Commute to Work	59
Business Related	10
Commute to Class*	9
Medical Appointment	7
Medical Visitation	2
Other**	13
Total	100

* A few LMA colleges were already on summer vacation when the survey was conducted.
** Includes shopping, personal business, social, recreational, and other travel.

Finally, the auto occupancy rate for LMA arterials during weekday peak periods was estimated at 1.3. Across all survey stations, 79 percent of automobiles had only one occupant, and another 15 percent had two occupants. Only six percent of automobiles at surveyed locations carried three or more occupants.

D. ROADWAY TRAFFIC CHARACTERISTICS

1. Historical Traffic Trends

In the 1975 study referenced earlier, mechanical recorder counts were conducted on various roadways within the LMA to obtain 24-hour average weekday daily traffic (AWDT) volumes. Additionally, a ten-year forecast of AWDT was made for 1985 volumes. These volumes for 1975 (actual) and 1985 (predicted) are shown in Table 18, along with 1987 (actual) volumes and the change in volumes over the 12-year period, 1975-1987. (See the following section for a detailed discussion of existing traffic volumes.)

TABLE 18
AVERAGE WEEKDAY DAILY TRAFFIC (AWDT)*

Location	1975 Actual AWDT	1985 Predicted AWDT	1987 Actual AWDT	Change in AWDT 1975-1987
Avenue Louis Pasteur south of Fenway	8,000	10,000	5,000	-3,000
Longwood Avenue east of Plymouth Street	8,000	11,000	8,000	0
Longwood Avenue east of Brookline Avenue	12,000	14,000	12,000	0
Francis Street east of Brookline Avenue	5,000	7,000	13,000	+8,000
Riverway north of Longwood Avenue	20,000	26,000	26,000	+6,000
Huntington Avenue north of Longwood Avenue	24,000	28,000	26,000	+2,000
Brookline Avenue south of Longwood Avenue	28,000	30,000	28,000	0
Brookline Avenue south of Pilgrim Road	27,000	27,000	29,000	+2,000
Riverway south of Brookline Avenue	33,000	35,000	38,000	+5,000

* Rounded to nearest thousand.

In general, traffic volumes have increased in the LMA over the 12-year period. The increases may be attributed to general traffic growth within and external to the LMA, and to increased residential and institutional development within the study area. Where traffic did increase, the increases ranged from 2,000 vpd (vehicles per day) on each of two roadway segments to 8,000 vpd on Francis Street east of Brookline Avenue. This great increase on Francis Street may be attributable to a variety of factors, including the construction of the Vining Street and Servicenter garages, the consolidation of four hospitals, and the restriction

of turning movements at the intersection of Fenwood Road and Brookline Avenue (which shifted traffic from Fenwood Road to Francis Street).

Several roadways showed no change in traffic volumes over the 12-year period, including both segments of Longwood Avenue, and Brookline Avenue south of Longwood Avenue. Avenue Louis Pasteur actually experienced a decline in volume over the 12-year period; the decline is likely due to the revised intersection configuration at Fenway that now prohibits direct access from Avenue Louis Pasteur to Park Drive.

2. Existing Traffic Volumes

Mechanical and manual traffic counts were conducted in April, 1987 and were supplemented with traffic volume data collected in November, 1986. Table 19 lists, for several locations, the 1987 average weekday daily traffic (AWDT), AM and PM peak hour traffic volumes, and the percent of daily traffic volumes which the AM and PM peak hour traffic volumes represent. Existing daily volumes are also graphically illustrated in Figure 13. Morning peak hour percentages of AWDT vary from a low of 5.5 percent on Brookline Avenue south of Longwood Avenue to a high of 8.2 percent on Longwood Avenue east of Plymouth Street. In the evening, the peak hour percentage of AWDT is lowest on Francis Street at 5.0 percent and reaches a high of 8.3 percent on Avenue Louis Pasteur. These differences in peak hour percentages are indicative of the varying functions of the roadways, with commuter roadways experiencing a higher percentage of usage during peak traffic periods.

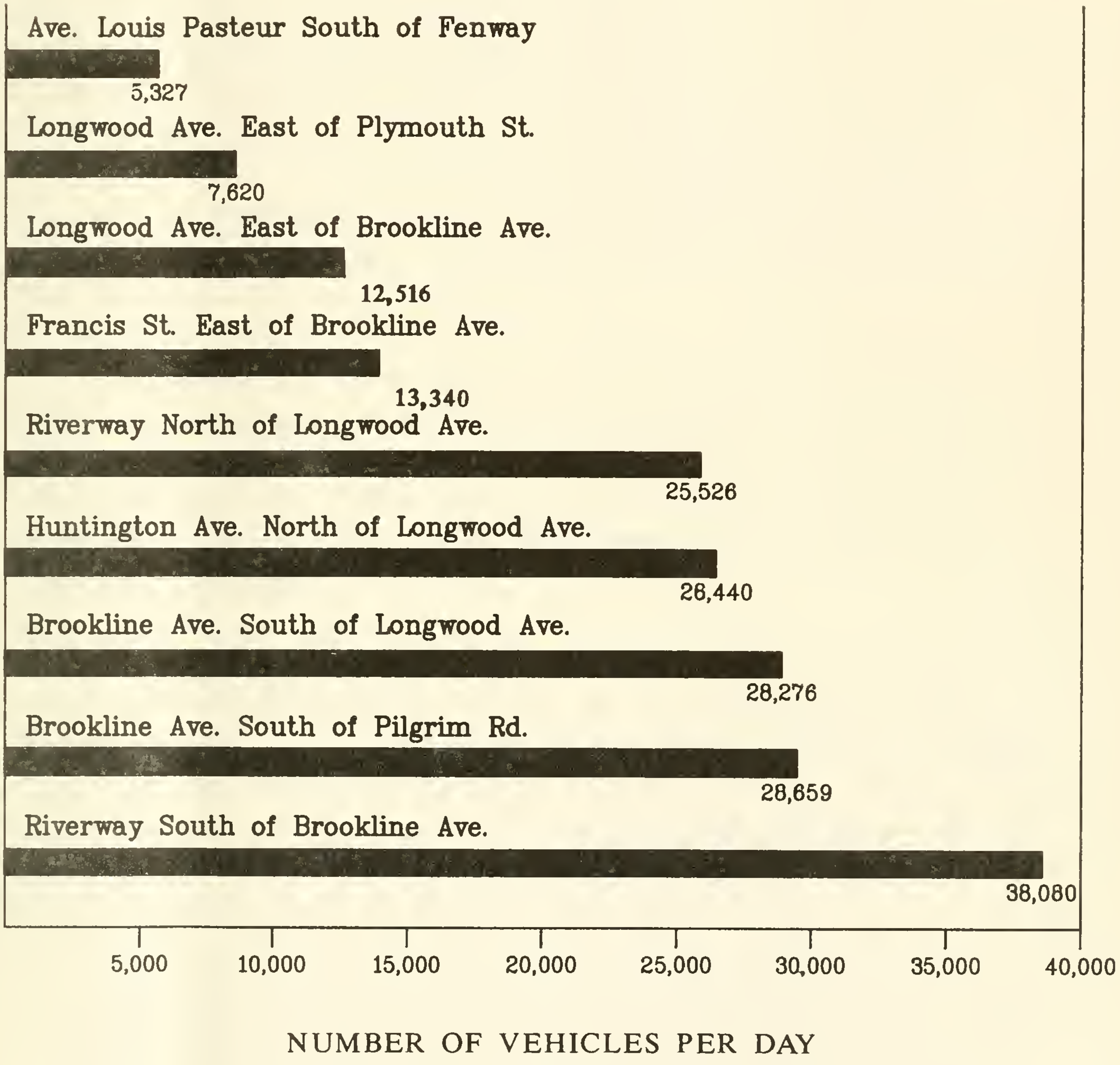
TABLE 19
TRAFFIC VOLUME SUMMARY

Location	AWDT*	AM Peak Hour (vph)**	Percent of AWDT	PM Peak Hour (vph)	Percent of AWDT
Avenue Louis Pasteur south of Fenway	5,327	410	7.7%	440	8.3%
Brookline Avenue south of Longwood Avenue	28,276	1,565	5.5%	1,745	6.2%
Brookline Avenue south of Pilgrim Road	28,659	1,885	6.6%	1,940	6.8%
Francis Street east of Brookline Avenue	13,340	935	7.0%	665	5.0%
Huntington Avenue north of Longwood Avenue	26,440	1,845	7.0%	1,920	7.3%
Longwood Avenue east of Brookline Avenue	12,416***	920	7.4%	980	7.9%
Longwood Avenue east of Plymouth Street	7,620	625	8.2%	615	8.1%
Riverway north of Longwood Avenue	25,526	1,635	6.4%	1,810	7.1%
Riverway south of Brookline Avenue	38,080	2,505	6.6%	2,755	7.2%

* AWDT - average weekday daily traffic, based on mechanical counts.

** vph - vehicles per hour, based on turning movement count data.

*** Estimate.



NOTE: COUNTS TAKEN BETWEEN NOVEMBER 1986 AND APRIL 1987

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Roadway 24 Hour Volume Summary

Fig. 13

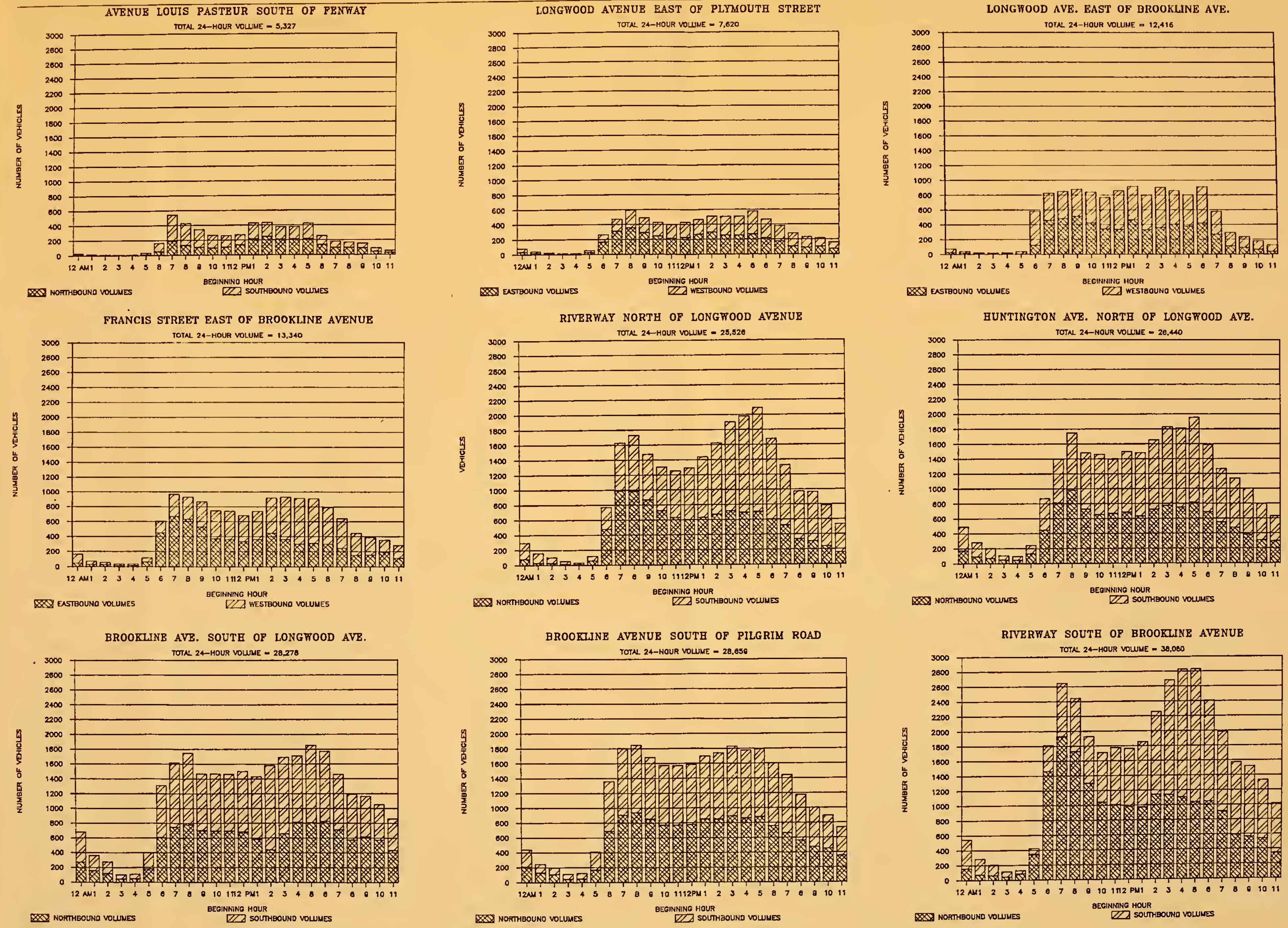
Among the nine locations counted, traffic volumes range from a low of 5,300 vehicles per day (vpd) on Avenue Louis Pasteur to nearly 38,100 on the Riverway south of Brookline Avenue. Although Francis Street appears to be slightly more heavily used than Longwood Avenue for east-west travel (13,300 vpd versus 12,400 vpd), this is true only on the short segment between Brookline Avenue and the Servicenter Garage. The mechanical counter was located on this segment of Francis Street and recorded many trips to and from the garage in addition to the regular Francis Street traffic.

The segment of Longwood Avenue east of Brookline Avenue carries considerably more volume (12,400 vpd) than the segment west of Brookline Avenue (7,600 vpd). This may be attributed to the high density of medical area land uses east of Brookline Avenue and to the fact that Longwood Avenue has a significant land access function.

Riverway traffic volumes are highest south of Brookline Avenue, since that segment carries the great majority of the volume shared fairly equally by the two roadways north of their intersection. Of the three major north-south routes through the study area, Brookline Avenue carries the greatest volume of traffic (27,000 vpd), closely followed by Huntington Avenue (26,400 vpd) and the Riverway (25,000 vpd).

Volume distribution by hour has been graphed for each of the nine mechanical recorder counts and is shown in Figure 14. In general, roadways with higher percentages of commuters tend to have significantly greater amounts of traffic volume during the peak commuting periods (generally 7:00 to 9:00 AM and 4:00 to 6:00 PM) than during the rest of the day. Roadways with significant amounts of local traffic, however, tend to have relatively small variations in vehicular volume throughout the day. This

Temporal Distribution of Traffic Volumes



NOTE: Mechanical Recorder Counts Taken Between November 1986 And April 1987

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Not to Scale

Fig. 14

peaking pattern for commuters can most readily be seen in the temporal distributions for the Riverway, while Longwood Avenue east of Brookline Avenue displays more evenly distributed volumes over the course of the day. On several roadway segments (Brookline Avenue south of Pilgrim Road, and Francis Street), traffic volumes peak during the mid-afternoon. These peaks are directly related to the nature of the LMA land uses, which attract and employ large numbers of students, nurses and other shift workers whose schedules tend to begin or end during the mid-afternoon.

The directional distribution on a roadway is the percentage of traffic flowing in each direction during a given time period. Daily and peak hour directional distributions are also displayed in Figure 14 and are further summarized in Table 20 for each of the peak hours. In general, morning peak hour flows are heaviest into the LMA, while the reverse pattern holds true for the evening peak hour. Huntington Avenue north of Longwood Avenue is the notable exception, with heavier northbound morning flows and southbound evening flows due to its main function as a commuter route into downtown Boston. Brookline Avenue south of Pilgrim Road has the most even flow distribution throughout the day and during each of the peak hours at 51 percent for each peak direction. This balance occurs because commuters working in the LMA and those working downtown travel in opposite directions on this segment. The Riverway south of Brookline Avenue exhibits the greatest directional variation of all arterials in the study area during peak hours, with 73 percent of its volume flowing northbound in the morning and 63 percent southbound in the evening. This significant imbalance between northbound and southbound flow during peak hours occurs because LMA commuters and downtown commuters travel in the same direction at the same time on this roadway segment.

TABLE 20
DAILY AND PEAK HOUR DIRECTIONAL DISTRIBUTION

	Daily		AM Peak Hour		PM Peak Hour	
Location	Percent	Direction*	Percent	Direction	Percent	Direction
Avenue Louis Pasteur south of Fenway	54%	SB	65%	SB	51%	NB
Brookline Ave. south of Longwood Ave.	52%**	NB	59%	NB	53%	SB
Brookline Ave. south of Pilgrim Rd.	51%	NB	51%	SB	51%	NB
Francis St. east of Brookline Ave.	52%**	WB	69%	EB	69%	WB
Huntington Ave. north of Longwood Ave.	55%	SB	56%	NB	58%	SB
Longwood Ave. east of Brookline Ave.	54%	WB	56%	EB	53%	WB
Longwood Ave. east of Plymouth St.	53%	EB	60%	EB	54%	WB
Riverway north of Longwood Ave.	56%	SB	57%	NB	66%	SB
Riverway south of Brookline Ave.	52%	SB	73%	NB	63%	SB

* EB=Eastbound; NB=Northbound; SB=Southbound; WB=Westbound.
** Estimate.

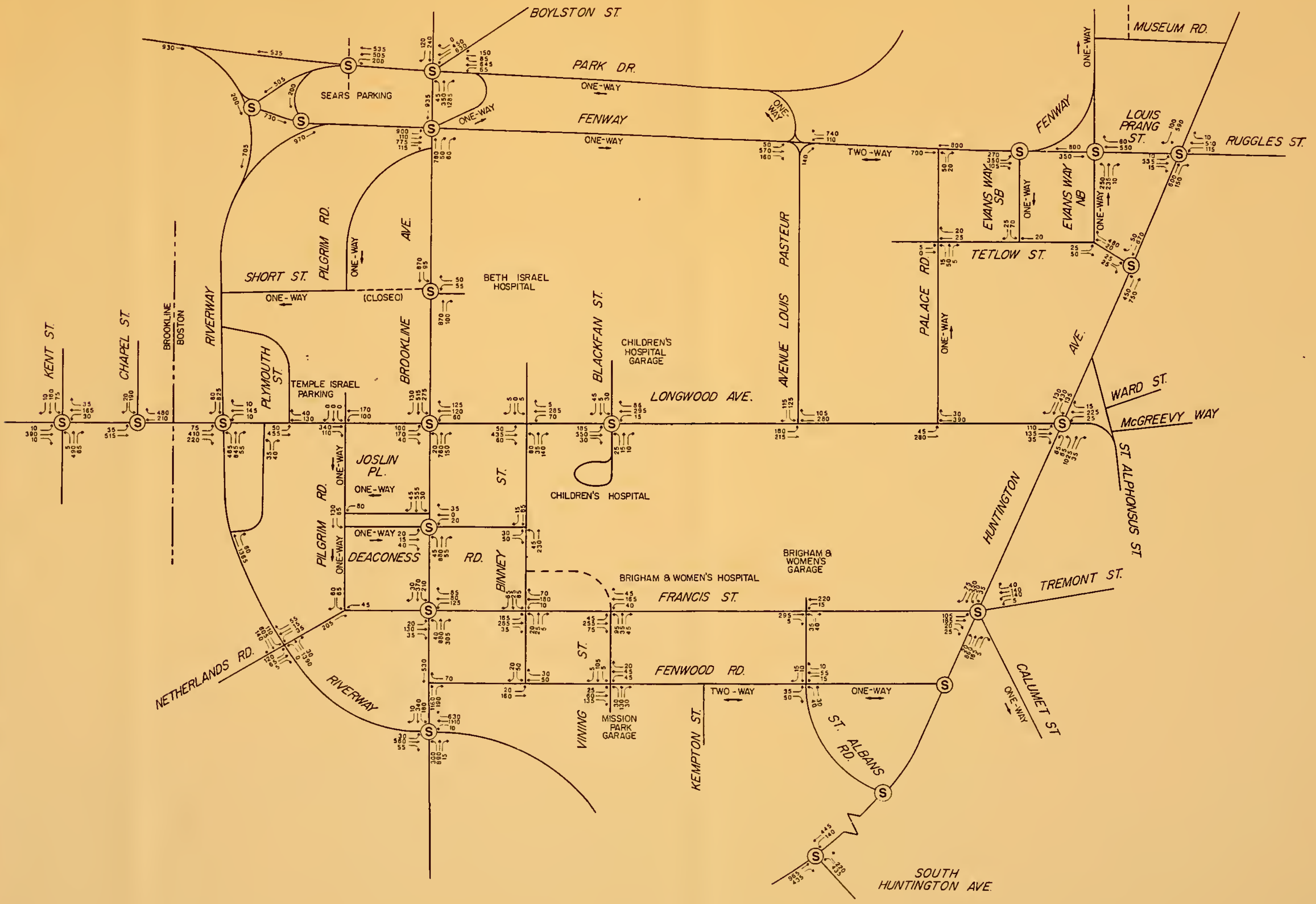
A typical roadway has a fairly balanced directional pattern over a 24-hour period, with about half of all traffic flowing in each direction. Variations occur when more attractive alternate routes exist for one particular direction than exist for the other. Factors which may affect opposite travel directions differently include signal progression, one-way designations, turn prohibitions, left turns, and tolls. In general, the study area roadways exhibit a relatively even 24-hour directional distribution. The most significant 24-hour imbalance occurs on the Riverway north of Longwood Avenue, where 56 percent of total daily volume flows southbound. Because of the congested rotary traffic pattern at the northern end of this segment, some northbound trips destined for the Boston University Bridge are shifted to Brookline Avenue and to Chapel Street.

Manual turning movement counts (TMCs) were conducted at numerous locations throughout the study area for both morning and evening peak periods (7:00-9:00 AM and 4:00-6:00 PM). Existing AM and PM peak hour traffic volumes are shown in Figures 15 and 16. Included on these graphics are the locations of traffic signals within the study area. The signals on Brookline Avenue at the Riverway, Francis Street, Deaconess Road and Longwood Avenue are all part of an interconnected system designed to improve traffic flow along Brookline Avenue.

3. Accidents

Accident data were examined to aid in identifying hazardous intersections and roadway segments. Accident data were provided by three sources: MASCO (from Medical Area Security Patrol incident reports and Boston Police Department records), the Metropolitan District Commission Police, and the Town of Brookline Police. The data were available for varying time periods, and thus each source was adjusted to reflect an "average

Existing A.M. Peak Hour Traffic Volumes



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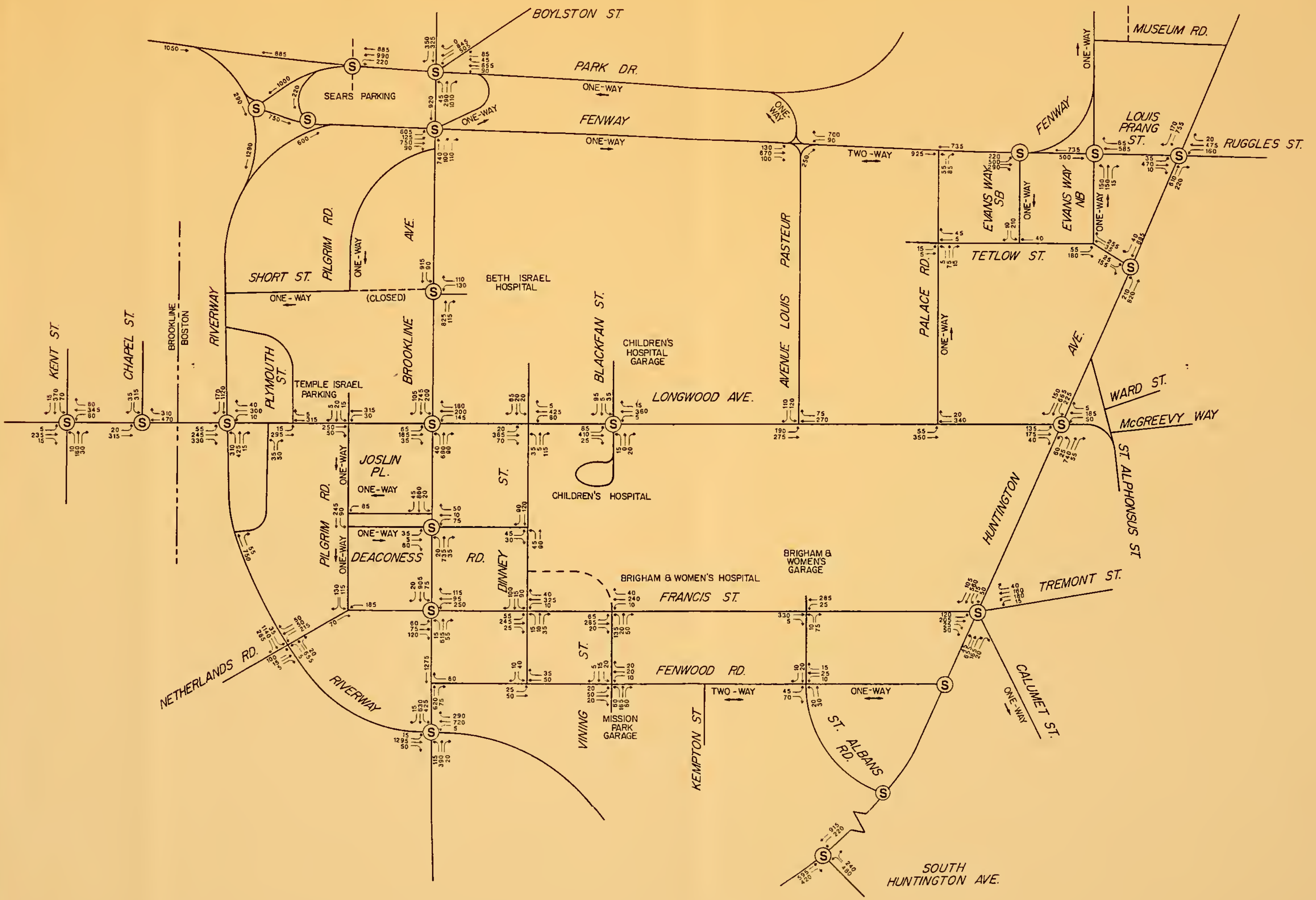
Not to Scale

Fig. 15

Existing P.M. Peak Hour Traffic Volumes



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Not to Scale

Fig. 16

annual" total number of accidents by location. The average annual figures from each of the sources were then totaled to derive a composite number of average annual accidents by location.

An estimate of 180 average annual accidents was derived from the incident reports, 137 of which occurred at intersections (including Longwood Avenue at Kent and Chapel Streets in Brookline). This figure represents 76% of the total recorded accidents, while the remaining 43 accidents occurred along various roadway segments, comprising 24% of total incidents.

Review of the data indicates that Longwood Avenue and Brookline Avenue, which traverse the core of the study area, where the highest degree of congestion exists, are two of the roadways with the highest number of accidents occurring on segments outside of an intersection. Nearly half (19 out of 42) of all roadway segment accidents were recorded on these two streets. Also identifiable are parallel corridors to each of these roadways, the Riverway and the Fenway, which also incurred significant numbers of accidents. The combined 33 accidents reported on these four roadways comprised 79 percent of the total of 42 accidents occurring on roadway segments. Table 21 summarizes roadway (non-intersection) accidents.

As might be expected, roadways with a significant number of accidents occurring on various segments often have high accident intersections along their lengths. Based on the data provided, intersections with four or more accidents are presented in Table 22.

TABLE 21
AVERAGE ANNUAL ROADWAY ACCIDENTS*

Roadway Name	Number of Accidents
Longwood Avenue	10
Brookline Avenue	9
Riverway	8
Fenway	6
Huntington Avenue	4
Francis Street	3
Vining Street	1
Evans Way	1
Total	42

* Excludes intersection accidents.

TABLE 22
HIGH-ACCIDENT INTERSECTIONS

Location	Number of Accidents
Brookline Avenue/Riverway	43
Riverway Longwood Avenue	17
Brookline Avenue/Longwood Avenue	9
Huntington Avenue/Francis Street	9
Brookline Avenue/Riverway/Jamaicaway	5
Brookline Avenue/Francis Street	5
Brookline Avenue/Short Street	5
Brookline Avenue/Fenway	5
Longwood Avenue/Kent Street	5
Total	89

The nine locations identified in Table 22 represent nearly 55% of all intersection accidents (89 out of 137) for a one-year

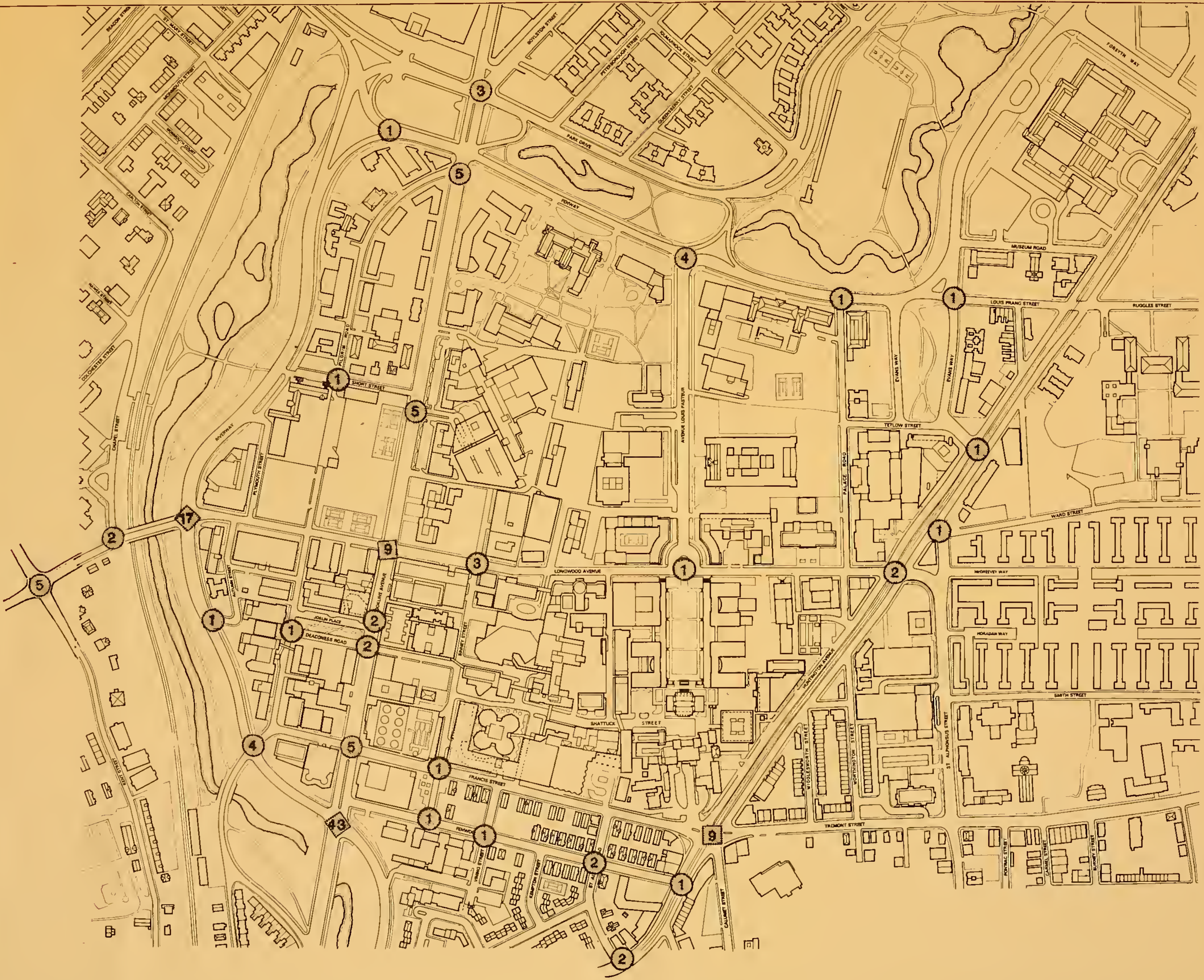
period. Accidents occurring at all study area intersections are graphically illustrated in Figure 17.

Once again, high-accident roadways are identifiable: the Riverway (65 accidents), Brookline Avenue, (74 accidents), Longwood Avenue (39 accidents), Huntington Avenue (16 accidents) and Francis Street (19 accidents). (The numbers cited include double-counted accidents where any two of these four roadways intersect). These statistics are attributable to the volume of traffic and the relative degree of congestion occurring along these roadways, in addition to any physical hazards such as stopping-sight distance, unchannelized pavement and conflicts with pedestrians.

E. PUBLIC TRANSPORTATION RIDERSHIP

MBTA boarding and alighting counts suggest that about 5,000 people arrive in the LMA on MBTA bus and light rail service between 6:00 AM and 9:15 AM on weekdays. As shown earlier in Table 11, about 2,000 riders come from the direction of downtown Boston on one of the two Green Line branches. The Arborway Line and its replacement bus route (Route 39) account for almost half of all MBTA commuters to the LMA; the service carries approximately 1,600 riders from the direction of downtown and approximately 800 from Jamaica Plain. Bus Route 47 is the second most popular transit route for LMA trips, carrying nearly 900 riders to the LMA each morning. Its high ridership results from its direct access to part of Roxbury and indirect access to the rest of Roxbury and Dorchester, where much of the LMA workforce resides.

The Riverside Line ranks a close third in importance to the LMA, carrying about 875 riders to Longwood Station. Approximately 60 percent of these passengers arrive from the west, while



Intersection Accident Locations

LEGEND:

Intersection Accidents

○ 1–5

□ 6–10

◇ 10–OVER

NOTE:

Data Provided by MASCO as Compiled From Medical Area Security Patrol and Boston Police Department Incident Reports, Metropolitan District Commission Police and the Town of Brookline Police

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0 250 500
SCALE IN FEET

Fig. 17

about 40 percent come from the direction of downtown. The remaining bus routes (Routes 60, 65 and 66) together carry about 750 passengers to the LMA, or 15 percent of the total.

F. RIDERSHIP ON OTHER TRANSPORTATION SERVICES

As shown earlier in Table 12, MASCO carries approximately 2,300 riders into the LMA during the morning commuter hour. Approximately 1,400 riders are satellite parking patrons, while the remaining 900 passengers are presumably boarding Metrobus near their residences in Cambridge, Allston and Brookline. Over 90 percent of the latter group board in Cambridge.

The 900 passengers who are not parkers may be added to the almost 5,000 MBTA riders to derive an estimated total of nearly 6,000 transit riders arriving in the LMA between 6:00 AM and 9:15 AM. MASCO bus passengers are virtually all workers and students at LMA institutions, while MBTA riders include visitors to those institutions as well as workers and visitors traveling to other destinations in or near the LMA.

Taxicab service is used for internal LMA trips and for daily commuting to the LMA. Some evening shift employees arrive at work via public transportation about 3:00 PM but prefer taxicabs over transit when leaving work at 11:00 PM, for convenience and security reasons. Taxicabs are also used by day shift workers who live fairly close to the LMA and do not have an automobile available for commuting.

G. CHARACTERISTICS OF PEDESTRIAN DEMANDS

There is a large volume of pedestrian traffic in the LMA. The 1980 U.S. Census indicated that about 17 percent of LMA work trips were made entirely on foot. Another 26 percent of work

trips were by transit, which always requires some use of the pedestrian network. Finally, the majority of workers and non-workers who drive to and from the LMA do not park at their final destinations and, therefore, travel on the pedestrian network. The affiliations and shared staff arrangements between LMA institutions also generate many trips between facilities, some of which are made on foot.

Students also tend to travel on public transit and on foot. Each day, hundreds of high school students cross Huntington Avenue at Longwood Avenue to travel between the two public high schools and the MBTA buses and streetcars. These pedestrian crossing movements are especially significant because they are tightly concentrated in two short time intervals.

An example of high pedestrian volumes in the LMA can be found at the intersection of Longwood Avenue and Brookline Avenue, where the total volume of pedestrians crossing Longwood Avenue is about 400 between 7:00 AM and 9:00 AM and about 600 between 4:00 PM and 6:00 PM on weekdays. The corresponding volumes for persons crossing Brookline Avenue at that location are about 1,300 in the morning and about 1,700 in the afternoon.

V. Transportation Effectiveness

V. TRANSPORTATION EFFECTIVENESS

This chapter is perhaps the most important part of the existing conditions report, because it identifies deficiencies in the LMA's transportation system. This chapter does not propose strategies for resolving those problems, as that is the role of the subsequent analysis and final report. Where possible, however, this chapter does shed light on possible causes of the deficiencies and, in some cases, touches on potential solutions.

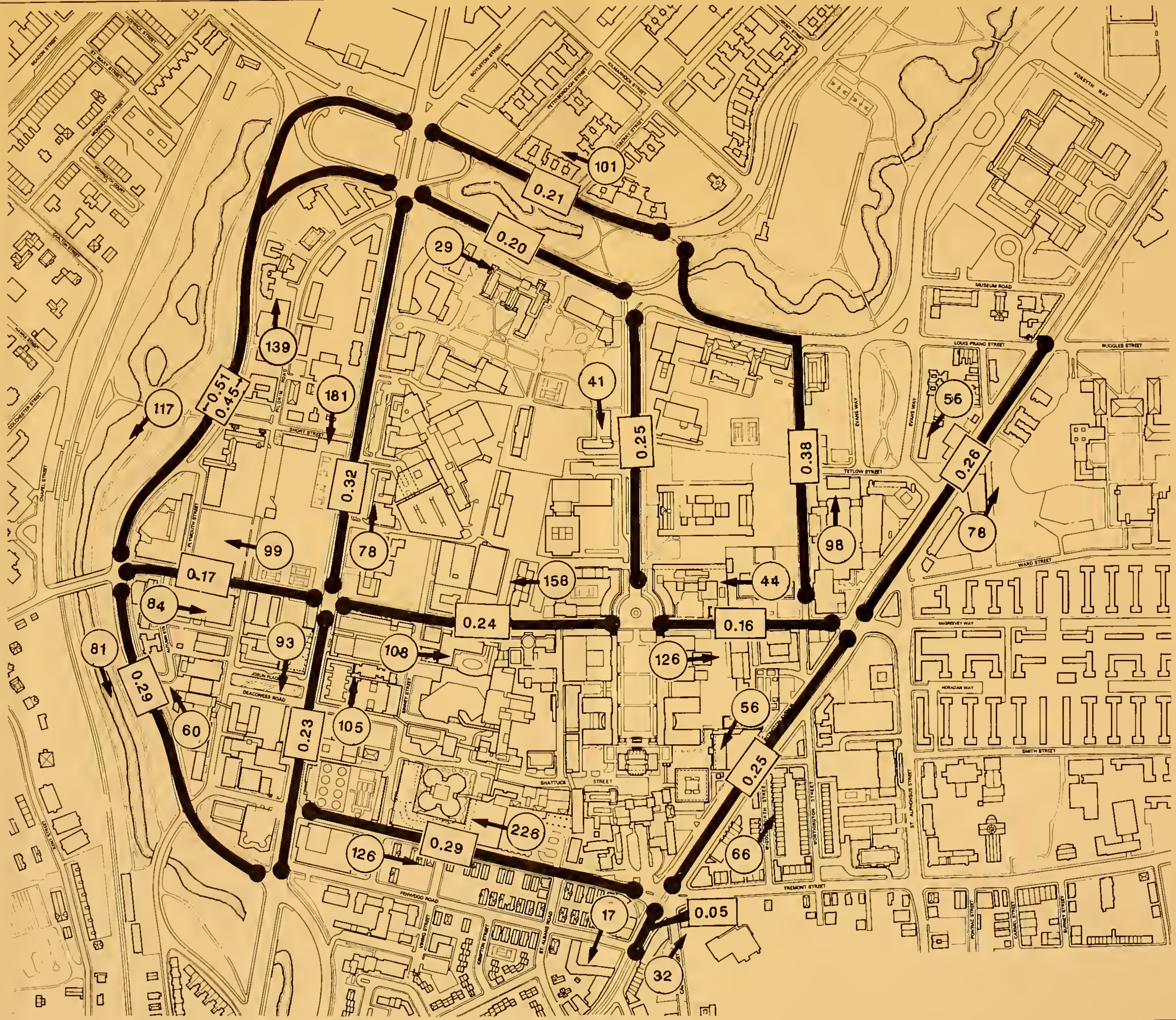
A. ROADWAY PERFORMANCE

1. Travel Time Analysis

Travel time runs were conducted on several major roadways and travel paths through the LMA study area. Average travel times between various points were measured along each selected route a minimum of five times during the peak hours. Travel times for both the AM and PM peak hours have been aggregated to reflect a composite peak hour travel time and are shown for various roadway segments in Figure 18 along with the distances of the segments. Travel times are reflective of turning movements made onto and off of the various roadway segments in the course of the exercise runs. Left turns, long queues or insufficient green time on an approach may significantly affect the observed travel times.

Generally, the Riverway produced faster southbound travel times, despite its longer distance, than did the parallel route along Brookline Avenue between the Park Drive/Boylston Street/ Brookline Avenue and the Riverway/Brookline Avenue intersections. The average southbound travel time on the Riverway was 198 seconds while that of Brookline Avenue averaged 274 seconds, a savings of 76 seconds in travel time for southbound drivers using the Riverway. Northbound run times averaged 199 seconds and 183

Area Roadway Travel Times And Distances



LEGEND:
X.XX Segment Length (Miles)
XX Segment Travel Time (Seconds)

NOTE: A.M. and P.M. Peak Hour Travel Times Have Been Aggregated

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0 250 500
SCALE IN FEET

Fig. 18

seconds, respectively, on the Riverway and Brookline Avenue, which translate to a slight savings (16 seconds) for northbound vehicles using Brookline Avenue. For northbound vehicles, the delays on Brookline Avenue occur mainly on the portion south of Longwood Avenue, while the delays on the Riverway occur mainly on the portion north of Longwood Avenue.

Travel time data for Huntington Avenue between Louis Prang Street and Fenwood Road show that northbound travel speeds are similar on all three north-south arterials, ranging from 11 to 13 mph, including delays. Southbound travel speeds show more variation, ranging from 7 mph on Brookline Avenue to 15 mph on both Huntington Avenue and the Riverway.

Analysis of east/west travel times indicates that, between Huntington Avenue and Brookline Avenue, eastbound speeds are slightly higher on Francis Street (8 mph), than on Longwood Avenue (6 mph), while westbound speeds are higher on Longwood Avenue (7 mph) than on Francis Street (5 mph). Eastbound speeds of 25 mph were measured on the Fenway between Brookline Avenue and Avenue Louis Pasteur, while westbound speeds of 7 mph were observed on the Park Drive segment east of Brookline Avenue.

The Longwood Medical Area is a very dense and congested urban area. Not only is there a relatively high volume of traffic moving through and within the area, but there are a significant number of pedestrians, traffic signals, turning vehicles at intersections, transit vehicles, and construction projects in the study area, all of which affect travel time by increasing delay to vehicles traveling on these roadways.

2. Signalized Intersection Analysis

• Analysis Procedures

Signalized intersections within the study area were evaluated using computer programs based on the 1985 Highway Capacity Manual procedures. Signalized intersection analysis considers a wide variety of prevailing conditions, including the amount and distribution of traffic movements, traffic composition, geometric characteristics, and the details of intersection signalization. Critical to the evaluation are the concepts of capacity and level of service (LOS), which must be considered together to evaluate the overall operation of a signalized intersection.

In this approach, capacity at intersections is defined for lane groups, rather than for approaches or the intersection as a whole. A lane group may be a single movement, a group of movements, or an entire approach and is defined by the geometry of the intersection and the distribution of movements over the various lanes. Capacity (C) of a lane group is calculated as the maximum rate of flow which may pass through the intersection under prevailing traffic, roadway and signalization conditions. The rate of flow (V) is generally measured or projected for a 15-minute period, and capacity is stated in vehicles per hour. Capacity analysis of intersections involves the computation of volume-to-capacity (V/C) ratios for each lane group, from which an overall intersection V/C ratio may be derived.

Generally, when two opposing flows are moving during a signal phase, one of the lane groups will require more green time than another in order to process all of its volume. This would be defined as a "critical" lane group for the subject signal phase. The concept of a critical V/C ratio is used to evaluate the intersection as a whole, considering only the critical lane

groups - those that have the greatest demand for green time within each signal phase. This procedure assumes that green time has been appropriately allocated. Thus, it is possible to have an overall intersection V/C of less than 1.00 (under-capacity), but still have individual movements be oversaturated within the signal cycle if the green time has not been appropriately allocated to the various approaches.

The other major concept in signalized intersection analysis is level of service, which is defined in terms of delay. Delay represents a measure of driver discomfort, frustration, fuel consumption, and lost time. Specifically, level of service delay criteria are stated in average stopped delay per vehicle for a 15-minute analysis period. The criteria are represented in Table 23.

TABLE 23
LEVEL OF SERVICE DELAY CRITERIA

Level of Service	Stopped Delay per Vehicle (sec)
A	≤5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	>60.0

Delay is a complex measure which depends upon a number of variables, listed in decreasing order of importance: the quality of signal progression; the cycle length; the allocation of green times; and, V/C ratios. Of note is that V/C ratios, of all the factors cited, have the least effect on delay. Thus, for any given V/C ratio, a range of delay values (and, therefore, level

of service) may result. Conversely, for a given level of service, the V/C ratio may lie anywhere within a broad range.

For the reasons stated above, both capacity and level of service must be carefully examined when analyzing a signalized intersection. The designation of an approach as operating at LOS F does not automatically imply that the entire intersection, approach or lane group is overloaded, nor does a level of service in the A to E range automatically indicate that there is unused capacity available. Simply stated, V/C ratios are a measure of the physical and operational characteristics of an intersection, while delay and level of service are an average measure of a driver's perception and experience at a particular intersection. Together these two parameters are used to evaluate signalized intersection performance.

• Level of Service Analysis Results

Signalized intersection analyses were conducted for 13 of the intersections within the LMA study area for both the morning and evening peak hours. The results of these analyses are listed in Table 24 in terms of volume-to-capacity ratios (V/C), delay, and level of service (LOS) for each intersection as a whole.

In the morning peak hour, 11 of the 13 intersections analyzed are operating at acceptable levels of service (LOS A-D), while two are operating at deficient levels of service (LOS E-F). The signals along Brookline Avenue between the Riverway and Short Street are interconnected to improve the progression and minimize delay as vehicles travel this roadway. With the exception of the Riverway/Brookline Avenue intersection, all intersections along Brookline Avenue operate at acceptable levels of service during the morning peak hour. The Riverway/Brookline Avenue intersection is calculated as having a V/C ratio of 1.07, or in other

words, is operating at seven percent over capacity. In actuality, the intersection is at or near capacity (V/C = 1.00), and actual vehicle flow rates were measured up to 2,200 vehicles per hour (vph) for certain approaches. This is well above the standard flow rate of 1,800 vph.

TABLE 24
SIGNALIZED INTERSECTION ANALYSIS SUMMARY*

	AM Peak Hour			PM Peak Hour		
Intersection	V/C	Delay (sec.)	LOS	V/C	Delay (sec.)	LOS
Riverway/Longwood Ave.	0.75	40	D	0.97	43	E
Riverway/Brookline Ave.**	1.07	60+	F	1.08	60+	F
Brookline Ave./Francis St.	1.01	17	C	0.81	20	C
Brookline Ave./Deaconess	0.49	6	B	0.53	10	B
Brookline Ave./Longwood	0.93	27	D	0.85	50	E
Brookline Ave./Fenway	0.71	32	D	0.68	18	C
Brookline Ave./Park Dr.	0.79	19	C	0.89	26	D
Huntington Ave./Ruggles St.	0.61	17	C	0.84	36	D
Huntington Ave./Longwood Ave.	0.89	28	D	0.98	32	D
Huntington Ave./Francis St	0.76	24	C	0.94	58	E
Huntington/S. Huntington	0.79	83	F	1.00	63	F
Longwood Ave./Chapel St.	0.47	7	B	0.62	12	B
Longwood Ave./Kent St.	0.72	22	C	0.71	16	C

* Analyzed with CINCH Program.

** Analyzed with McTrans program to allow use of actual observed flow rates. Program does not calculate delays greater than 60 seconds.

The intersection of Brookline Avenue and Francis Street was also calculated as operating at capacity (V/C = 1.01), but the overall intersection level of service is C during the AM peak hour. This indicates that the V/C ratios are over capacity for certain movements (in this case, the left turn into Francis Street eastbound from Brookline Avenue southbound and the left

turn out of Francis Street westbound to Brookline Avenue southbound), and the intersection as a whole is processing as much volume as possible, but that the average delays incurred by drivers is acceptable. For analysis purposes, some of the critical left turn volume southbound on Brookline Avenue was eliminated to account for the propensity for these vehicles to "jump the green light" and to also account for major gaps which occur in the northbound flow due to the signal phasing downstream at the intersection of the Riverway/Brookline Avenue. These two situations, along with the fact that northbound drivers stopped by congestion often leave a gap to allow the southbound left turners to move, all contribute to a greater volume of vehicles being processed than the calculated capacity allows for in the analysis methodology.

Three of the four signalized intersections analyzed along Huntington Avenue operate at acceptable levels of service (LOS C or D) in the morning peak hour. The intersection of Huntington Avenue/South Huntington Avenue has an overall V/C of 0.79, but operates at Level of Service F due to the large number of left turning vehicles out of Huntington Avenue which incur excessive delays, pushing the average delay to all drivers over 60 seconds (LOS F). The three remaining intersections along Longwood Avenue at Kent Street, Chapel Street and the Riverway all operate at acceptable levels of service during the morning peak hour.

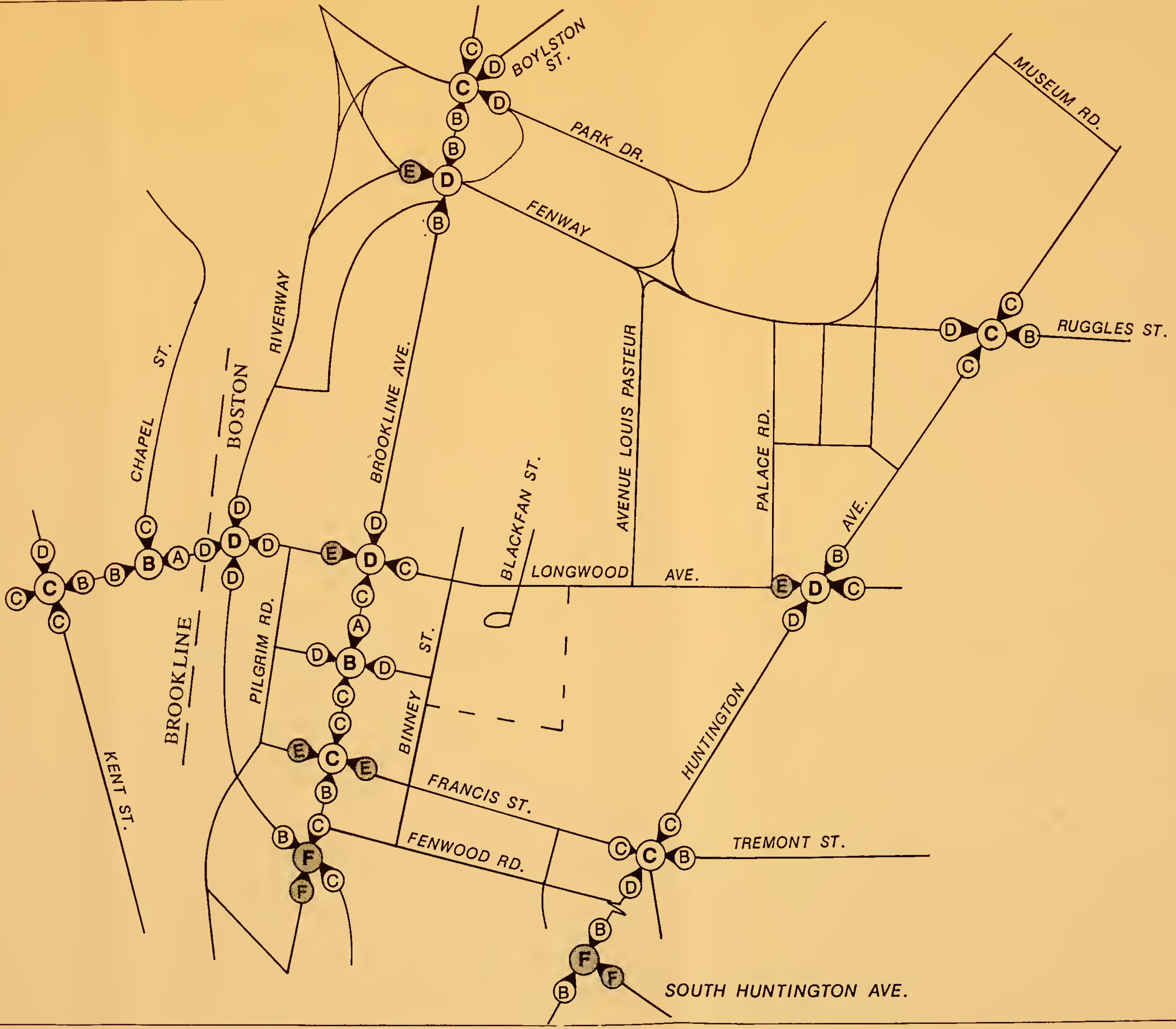
It should be noted that the analysis techniques employed focus on the operation of the intersection itself and its ability to process vehicles. Congestion in the vicinity of the intersection and queues backing up through the intersection are not taken into account in these procedures, and thus additional delay to the driver may be incurred beyond that attributable to the operation of the intersection itself.

During the evening peak hour, eight intersections operate at acceptable levels of service, while five intersections operate at deficient levels of service (LOS E or F). Typically, PM peak hour levels of service are worse than those of AM peak hours since more vehicles use the roadways during this time period. In the evening peak hour, both intersections examined along the Riverway, at Longwood Avenue and Brookline Avenue, are at or near capacity (V/C = 1.00), as are the Huntington Avenue intersections at Francis Street and South Huntington Avenue. In each of these cases, the V/C ratio is very high, and the delays incurred indicate deficient levels of service. The other deficient locations, Brookline Avenue/Longwood Avenue, has a V/C of only 0.85, which indicates that the signal timing and/or progression is not the most advantageous at this location. In general, the other signalized intersections operate at good levels of service; however, this measure may not be indicative of actual delays incurred due to congestion backing up through the analysis intersections.

Figures 19 and 20 schematically show the levels of service by approach and for the intersection as a whole for each of the analysis locations during the morning and evening peak periods. The AM peak hour graphic shows that delay along the main approaches to an intersection along the major arterials are generally acceptable (LOS A-D), with a few exceptions: the northbound approach on Brookline Avenue at the Riverway and the eastbound approach on the Riverway at the Brookline Avenue/Fenway intersection. Eastbound travel on Longwood Avenue between the Riverway and Huntington Avenue also tends to be somewhat delayed, as are several approaches on minor streets.

In the evening peak hour, excessive delays again occur on Longwood Avenue eastbound at Huntington Avenue and on both Longwood Avenue approaches at the Riverway. West of the

Existing Intersection Level Of Service A.M. Peak Hour



LEGEND: ○ = Intersection Level Of Service
Approach Level Of Service

NOTE: Shading Indicates Deficient Location

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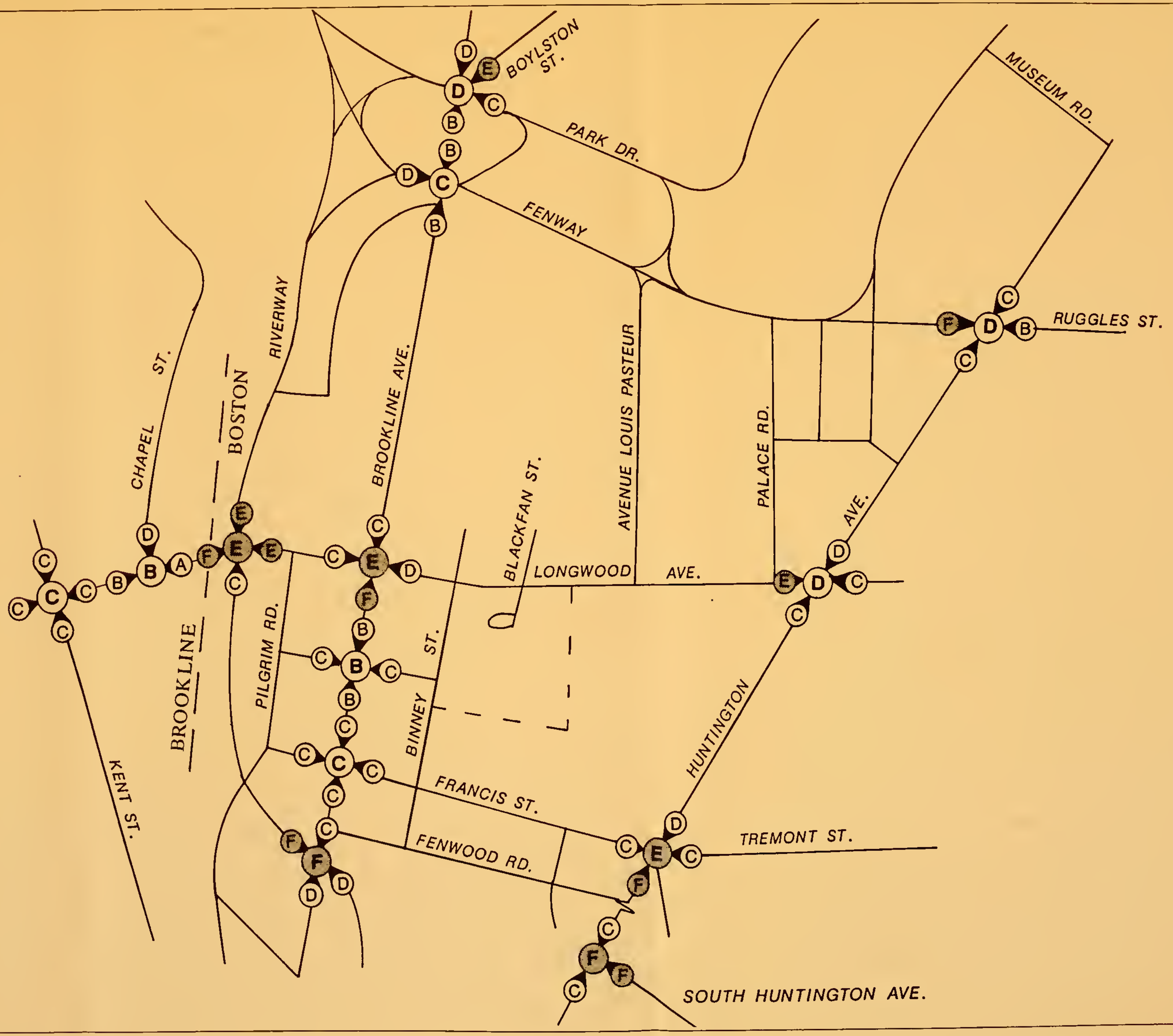
Not to Scale

Fig. 19

Existing Intersection Level Of Service P.M. Peak Hour



LEGEND:
○ Intersection Level of Service
ó Approach Level of Service

NOTE: Shading Indicates Deficient Location

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Not to Scale

Fig. 20

Riverway, all approaches have acceptable delays on Longwood Avenue. In the evening, only three approaches to intersections on Brookline Avenue have long delays: Southbound on Boylston Street, northbound on Brookline Avenue at Longwood Avenue, and eastbound on the Riverway. Huntington Avenue, too, has several problem approaches: eastbound on Louis Prang Street, northbound on Huntington Avenue at Francis Street, and on the South Huntington Avenue approach. Since most of the intersections with poor approach delays have V/C ratios close to capacity, signal improvements alone most likely would not improve the level of service to any significant degree.

B. PUBLIC TRANSPORTATION PERFORMANCE

Three important measures of the effectiveness of transit service are route structure, service hours and frequency. The MBTA's basic route structure is not well suited to the LMA. The MBTA system consists principally of radial rail lines emanating from downtown Boston, and bus routes designed to feed those lines. As a result, MBTA bus routes are shorter than those in other cities, and nearly all MBTA bus routes terminate at rapid transit stations rather than providing through service.

The clearest example of the route structure's adverse impact on the LMA is Ruggles Station, which lies just one mile from the intersection of Longwood and Brookline Avenues in the heart of the LMA. From Ruggles Station, a dozen feeder bus routes fan out through Roxbury and Dorchester, bringing a vast labor pool to the Orange Line. None of these feeder lines goes the extra mile to the LMA. Route 47, a crosstown route serving a very small portion of Roxbury, is the only bus route which passes through Ruggles Station rather than terminating there. Passengers on all other Ruggles Station bus routes must transfer at Ruggles to

Route 47 to reach the LMA. The transfer takes extra time and makes the transit option much less convenient.

Service hours and frequency, which were discussed and tabulated in an earlier section, are quite good for day shift employees on all MBTA routes in the LMA. The infrequency of bus service in the late evening is a serious deterrent to transit use by second- and third-shift workers. Late night service on the two Green Line branches is very frequent, but personal security is an issue for passengers walking to those two lines at night.

Besides route structure, service hours and frequency, reliability is the most important attribute of a transit service, particularly for work trips. Reliability is the degree of certainty that the rider will get to the destination on time. Perception by workers that a transit route is unreliable will deter ridership whether or not the perception is correct.

As part of the MBTA's 1984 Central North Bus Study, MBTA riders were asked to rate service reliability on many bus routes, including the four routes serving the LMA. The results were consistent with the fact that reliability problems tend to occur on higher-frequency routes and on routes serving commercial and densely populated areas such as the inner city. On the less frequent LMA routes, 60 and 65, both of which serve residential areas of Brookline after leaving the medical area, approximately 55 percent of survey respondents rated the service reliability as good or excellent, while just 17 to 18 percent rated these routes as poor or very poor. On the more frequent routes, both of which service Roxbury and other densely populated areas, less than half as many riders (26 percent in each case) rated the service reliability as good or excellent, and nearly twice as many riders (33 to 34 percent) rated these routes as poor or very poor in terms

of reliability. These results are presented in more detail in Table 25.

TABLE 25
PERCEIVED RELIABILITY OF SERVICE ON LMA BUS ROUTES

Route	47	66	60	65
Excellent	13%	12%	28%	23%
Good	13%	14%	27%	31%
Average	41%	40%	28%	28%
Poor	11%	17%	9%	10%
Very Poor	22%	17%	8%	8%
Total	100%	100%	100%	100%

The Green Line's reputation for unreliable service stretches back at least 15 years, and the Arborway branch, which serves the eastern portion of the LMA, is the most unreliable branch of all. On most of the Arborway line, streetcar tracks lie in the regular vehicle travel lanes, so that streetcars are subject to the same unpredictable traffic delays that automobiles experience. In commercial areas, delivery vehicles occasionally double-park on the tracks, resulting in very long delays.

Between Brigham Circle and the subway portal near Northeastern University, the MBTA tracks lie in a reservation in the median of Huntington Avenue. Streetcars are still delayed by traffic signals and turning automobiles, but travel times are more predictable on this segment. Therefore, the streetcar service currently operated between Brigham Circle and downtown Boston is more reliable than the former Arborway streetcar service was. However, unreliability, with its accompanying delays and overcrowding, is still frequently cited by users of the Brigham Circle streetcars.

The Riverside (D) line, on the western fringe of the LMA, is the most reliable of the Green Lines because the Highland Branch, on which it operates, is an exclusive right-of-way with no grade crossings. Nevertheless, there are three sources of unreliability on the Riverside line. The first is a shortage of vehicles, resulting in overcrowding of trains and long delays at stations. The second is streetcar traffic congestion in the Central Subway, where all four branches share the same track, causing unpredictable delays. The third is mechanical problems with the light rail vehicles (LRVs) purchased from Boeing-Vertol in the 1970s. These LRVs often break down, causing severe disruptions to service.

All of these sources of unreliability are being addressed, and reliability seems to be improving as a result. One hundred new LRVs, recently purchased from Kinki (Japan) have begun to arrive in Boston. These new cars will alleviate (but not eliminate) the equipment shortage and also allow the MBTA to remove from service the most troublesome of the Boeing cars. Also, about two years ago, transit consumer groups persuaded the MBTA to operate two-car LRV trains during rush hours to reduce Central Subway congestion. (A few years earlier, the MBTA had decided to discontinue two-car LRV trains in an attempt to decrease passenger wait time. The strategy failed because average wait time is influenced not only by the average headway but also by reliability.)

As part of this study, observations of service capacity, ridership, wait time and crowding were made at Longwood Station on the Riverside Line. (Because the Arborway streetcar line is currently suspended, with restoration uncertain, similar data were not collected on that branch.) Observations focused on the afternoon rush hour (3:30 to 6:30 PM) because unreliability problems are most prevalent at that time. Four days (spread over

two weeks) were sampled. On average, 368 inbound passengers and 345 outbound passengers boarded trains during the three-hour period observed.

The wait time results showed that service at Longwood Station is apparently much more reliable than is widely perceived. This is not very surprising because it is well known that it takes a year or two for riders (and three or four years for non-riders) to change their perceptions of service quality after the quality has improved. (Perception of a decline in service quality is much more rapid.)

Reliability is measured by comparing the extremely long wait times with the average wait times. For LMA workers and others boarding inbound (Boston-bound) trains between 3:30 and 6:30 PM, average wait time was 3 to 3 1/2 minutes on each of the four sampled days. On the worst of those days, only 27 percent of inbound boarding passengers waited more than five minutes, while three percent waited more than ten minutes, and no one waited more than 15 minutes. Inbound passenger loads observed on April 28 and May 6 were so low that most passengers boarding inbound trains at Longwood found available seats, and no one encountered an overcrowded inbound train. This is not surprising, because the heavier flows on the Green Line in the late afternoon are outbound from downtown Boston.

Outbound service at Longwood in the afternoon was also found to be quite reliable, though not as reliable as inbound service. For LMA workers and others boarding outbound (Newton-bound) trains between 3:30 and 6:30 PM, average wait time was four minutes on every observed day except on April 28, when an unseasonable snowfall occurred and wait time averaged five minutes. On the day of the snowfall, reliability was lowest. Of outbound passengers at Longwood, 38 percent on the snow day and

29 to 34 percent on the other three days waited more than five minutes. Fourteen percent on the snow day versus 4 to 10 percent on the other three days waited more than ten minutes, six percent versus 0.9 percent waited more than 15 minutes, and 1.6 percent versus 0.0 percent waited more than 20 minutes.

For outbound passengers, train capacity is a concern because the heavy flow of passengers riding through the LMA from downtown Boston out to Brookline and Newton often results in overcrowded conditions for LMA workers and students boarding outbound trains at Longwood, especially since passengers boarding at Longwood are unlikely to be among the seated passengers on a crowded train. Data collected by Vanasse Hangen Brustlin, Inc. in the fall of 1986 revealed overcrowding on outbound Green Line trains in the downtown area. On average, outbound LRVs in the busiest hour were carrying about 173 passengers, 33 percent more than their normal capacity of 130 passengers, the figure used for service planning by the MBTA Operations Department.

The ridership data collected at Longwood Station in the spring of 1987 are more positive. Outbound LRVs leaving Longwood Station on April 29 and May 5 carried an average of just 78 passengers in the busiest hour, and an average of only 69 passengers for the three-hour period as a whole. Load factors were highest on April 29 between 5:00 PM and 6:00 PM, when the average LRV carried 89 passengers, 68 percent of its planning capacity.

The mere fact that adequate capacity is provided on average is no assurance that overcrowding does not occur on particular trains due to uneven passenger loads. This often occurs on bus and rail lines when passengers arrive at stations in sudden bursts (e.g., at 5:00 PM) or when vehicles arrive at irregular intervals. These problems, particularly the latter, have been

prevalent on all Green Line branches in recent years, especially on the Arborway line due to its operation in mixed traffic.

The data collected at Longwood Station indicate that overcrowding due to uneven passenger loads is still a problem on the Riverside Line. During the two afternoons (six hours in all) when passenger loads on outbound trains were observed, eight percent of the 61 cars on May 5 and 16 percent of the 62 cars on April 29 carried loads in excess of planning capacity (130 passengers). The problem is clearer when presented (as it should be) in terms of passengers instead of cars. Since overcrowded cars carry more passengers, 15 percent of the 367 passengers boarding outbound trains at Longwood on May 5 and 31 percent of the 320 such passengers on April 29 rode in the overcrowded trains. The problem was most acute between 5:00 and 6:00 PM on April 29. Although ridership during that hour was only 68 percent of planning capacity, so that no one should have had to ride an overcrowded train, faulty dispatching of available cars caused 43 percent of passengers boarding outbound trains at Longwood during that hour to ride in overcrowded conditions. For an LMA worker on a regular 9-to-5 schedule, daily use of the Riverside Line outbound for the trip home means facing overcrowded conditions on two afternoons per week on average.

A frequent complaint of Green Line riders and a deterrent to transit use in the LMA is that trains sometimes pass a station without stopping to pick up passengers. On the Riverside Line, Longwood Station is among the five stations most often bypassed in order to speed service and reduce average wait times on the line as a whole. On the four afternoons analyzed by Vanasse Hangen Brustlin, the number of non-stop outbound cars at Longwood ranged from three (five percent) on April 28 to six (11 percent) on May 6, while the number of non-stop inbound cars ranged from zero on April 29 and May 6 to five on May 5. On this subject as

well, speaking in terms of passengers instead of trains makes the problem clearer. Only the April 29 data clearly show how many passengers were bypassed at Longwood. Though only seven percent of all outbound cars and eight percent of all outbound trains passed through Longwood Station that afternoon without stopping, 14 percent of outbound passengers were on the platform when one of these trains passed without stopping.

The favorable wait time data presented earlier suggests that the express trains are achieving their objectives. Since the wait time calculations are based only on trains that stop, they already include the extra wait time caused by non-stop trains. Without the express trains, wait times would definitely be longer systemwide and probably longer even at Longwood Station. Still, little is known about how passengers value the trade-off, and it is suspected that passengers would prefer to endure somewhat longer waits in order to avoid the experience of being bypassed.

To summarize the Riverside line data, about 370 inbound passengers and about 350 outbound passengers board at Longwood Station between 3:30 and 6:30 PM. Most inbound passengers wait less than five minutes and then get a seat on a lightly loaded train. Most outbound passengers also wait less than five minutes, but nearly all have to stand, and over 40 percent ride on cars loaded beyond their planning capacity. Fourteen percent of outbound passengers see an outbound train go by without stopping, and one or two percent decline to board an overcrowded train, preferring to await the next arrival. In short, service is efficient in both directions, but comfortable only for inbound passengers.

Another deterrent to use of MBTA service by LMA commuters is a lack of comfortable waiting facilities. MASCO began a program of bus stop improvements two years ago through the construction

of custom-designed bus shelters at key bus stops. Three have been installed at stops where adequate space was available. In addition, two member institutions have constructed shelters on their property as a convenience to their staffs. Even with these improvements, the amount of sheltered seating and standing room at bus stops and rail stations is inadequate at most locations and non-existent at several locations. For example, at Longwood Station on the Riverside Line, the shelter on the inbound platform can hold less than half of the 25 inbound passengers who typically accumulate at least once during the afternoon rush hour. On the outbound platform, no shelter is provided.

C. QUALITATIVE ASSESSMENT OF OTHER TRANSPORTATION SERVICES

MASCO Bus Routes M1 and M4, which serve satellite parking facilities near the LMA, generally provide good service. The service is frequent (every eight minutes at peak times), load factors are very comfortable, and there is sufficient slack time in the schedule to assure reliable service. The main drawback of Route M4 is the lack of non-emergency midday service.

On the other hand, MASCO Bus Route M5, serving the Western Avenue remote parking facility, as well as neighborhoods along the route, needs to be improved, and MASCO is currently evaluating alternative strategies. The service is reliable but infrequent, operating at 17-minute intervals in the morning and 30-minute headways in the afternoon. This route's low patronage is evidence that the combined park-and-ride price of $38 per month is not low enough to offset the inconvenience, and that the monthly fare of $27.30 for passengers who do not park is likewise too high.

MASCO Bus Route M2, serving Cambridge, offers excellent service as evidenced by its high ridership level. Its frequent

service, comprehensive service hours (18 hours per day, six days per week), and zero-fare policy for Harvard Medical School students and employees are made possible by separate funding from Harvard University.

The most serious deficiencies in other transportation services are in the area of information services. MBTA bus schedules and the MBTA route system map are not readily available to LMA commuters. They are usually not available on MBTA buses and trains. Furthermore, the schedules do not indicate when buses arrive at or depart from the LMA. The schedules give only the departure times from each end of the route, which may be several miles away. When buses are scheduled to run every 10 minutes or more frequently, the public time tables do not give any departure times at all.

The MBTA route system maps are rarely updated; the most recent one is five years old. Since it was published, the MBTA has changed dozens of bus routes and opened 13 new rapid transit stations and 14 commuter rail stations.

A specific example of information deficiencies in the LMA can be found on MBTA Route 47, which was recently extended beyond Boston City Hospital to Andrew Station on the Red Line to accommodate LMA commuters residing along the Red Line's Dorchester and Braintree branches. Although the route extension took effect May 2, 1987, as of August 17, the destination signs on many of the buses serving Andrew Station had not yet been changed to reflect the new destination. Thus, LMA commuters who could benefit from the bus route extension walk down Longwood Avenue to Huntington Avenue and take the Green Line all the way downtown, while buses destined for Andrew Station travel along Longwood Avenue bearing incorrect information.

D. QUALITATIVE ASSESSMENT OF PEDESTRIAN SERVICES

The quality of pedestrian ways in the LMA is generally poor. Pedestrian signals are provided at most crossing locations, but many sidewalks are in disrepair, and some are blocked by construction projects. Sidewalks are generally narrow, with few of the amenities commonly found in districts with high daytime populations. Considering the LMA's large workforce, there is very little outdoor retail activity, urban landscaping, seating and entertainment, to enhance the pedestrian environment. On the positive side, some improvements have been made in the last few years; MASCO has installed 50 seating benches, over 100 trees and 600 flowering shrubs in small areas along major pedestrian routes.

Improved sidewalk amenities and lighting would make both the transit mode and the walk mode more pleasant and attractive. For example, a potentially pleasant and convenient route from the Beth Israel Hospital and Winsor School to Longwood Station passes over the Muddy River in the park designed by Frederick Law Olmsted. Unfortunately, the route is marred by broken glass, uneven pavement and a lack of lighting, making it unsafe and unusable. In addition, this route crosses the Riverway near a sharp curve and without a pedestrian signal. Almost all LMA commuters are forced to detour to Longwood Avenue because of these deficiencies. Fortunately, the Boston Parks and Recreation Department and the Massachusetts Department of Environmental Management are planning to upgrade the park in the coming years.

VI. SUMMARY AND CONCLUSION

A. SUMMARY

The LMA is intensively developed, with an estimated 23,000 workers employed at 20 institutions within one-quarter of a square mile. In general, traffic volumes have increased in the LMA over the last 12 years, related to general traffic growth within the LMA and in the City of Boston. Approximately 65 percent of all peak hour traffic on LMA arterials is through traffic.

Despite the variety of work shifts at the medical institutions, there is still a preponderance of 8:30 to 5:00 workers. An estimated 56 percent of work trips are made by automobile, 71 percent of which are solo trips, and 26 percent of work trips are made by transit. These commuting patterns, combined with the high percentage of through traffic, result in deficient peak hour levels of service on all arterial roadways in the study area. Employee work trips made by single occupancy vehicles, combined with a growing need for patient and visitor parking in the LMA, have also caused a parking shortage within the LMA, necessitating the development of remote parking facilities and related shuttle bus services.

The regional public transportation network is designed for downtown workers and thus is not well suited to the LMA. The system of radial rail lines and feeder bus routes results in a need for transfers to reach the LMA from most Boston neighborhoods and surrounding communities. In addition, every transit route which serves the LMA exhibits at least two of the following deficiencies: overcrowding of transit vehicles, unreliable service, infrequent evening and weekend service, and inadequate passenger waiting facilities. A lack of accurate route and schedule information is a further deterrent to transit use.

B. CONCLUSION

This Summary of Existing Conditions presents a comprehensive inventory of the LMA land uses and its transportation system. Pertinent to an understanding and evaluation of the performance of the LMA as an urban sub-system, the report documents daily and peak hour conditions based on transportation planning and engineering principles. Both quantitative and qualitative analyses highlight traffic congestion and service deficiencies which exist today. Additionally, the information provides characteristics of transportation demand important to the consideration of transportation improvements.

Any compilation of existing conditions provides a reference point--a picture of conditions at one point in time. This current picture will be used immediately as a comparison in the next phase of the study with a five-year projection of growth and development for the LMA. Problems and transportation needs will also be projected, and the LMA conditions will be considered within the context of future development and its impacts on the transportation system.

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